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"THE PRESENT STATUS OF HIGH SCHOOL PHYSICS."[1]

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In considering this subject, the present status of high school physics, it seems fitting and proper that both high school and college teacher should participate. It has been said that the high school resents interference on the part of university. This may be true, and indeed it is perfectly natural, so far as *interference* is concerned, when it comes to the question of *coöperation,* however, the case is entirely different. In matters that relate to educational advancement, high school and university should stand together, for there never was a time when the interests of the one were so closely linked with that of the other as is the case to-day; hence it will not be out of place for a representative of a university to discuss a topic which bears directly upon the high school.

We are all more or less well acquainted with the history of the development of high school physics—acquainted with its remarkable advance in recent years; its elaborate methods; its satisfying-disappointing results. Also are we acquainted with the fact that there is today an unrest among physics teachers which is becoming more and more pronounced—an agitation which manifests itself in public discussion and private debate; in the resolutions of associations and the reports of committees; and especially in a plethora of elementary texts each heralded, in its preface, as a sure antidote for the ills, pedagogic and otherwise, which have fallen upon us. That there is such an agitation, deep and wide spread, no one acquainted with the facts will deny; just what this agitation for reform signifies, however, few seem to know.

In discussing this subject, I have no pet method to exploit; no special plea to make. I wish to take a philosophical rather than a pedagogical view of the subject. I propose to sum up the facts

[1] Address delivered before the Physics Section of the Central Association at its St. Louis meeting, November 30, 1907.

of the present situation; I desire to review the causes which have given rise to this so called "New Movement" for reform; and in conclusion, I wish to point out certain principles which should govern a reform, if reform be necessary.

Now, a careful study of the whole situation—that is to say a study of the various phases of this agitation which have led up to what has generally come to be known as the "New Movement"—reveals some very interesting and at the same time some exceedingly suggestive facts.

In the first place for example, this state of unrest is of comparatively recent origin. To appreciate the force of this remark one needs but to recall that it is not more than a dozen years since high school physics plumed itself as being one of the elect, and its complacency was equalled only by the envy with which it was regarded by certain other high school studies.

And second, that this subject has aroused an unusual interest, not only among high school teachers but among college men as well, is evidenced by the number and warmth of the discussions which have occured within the past year or two. For example, in one of our educational journals—the most prominent that represents the interests of our high schools—there recently appeared in five consecutive numbers no less than seven articles bearing on some phase of the subject of reform in the teaching of high school physics; and the greater number of these articles were characterized by a tone so dogmatic as to be truly representative of the school-master spirit. Indeed in this whole discussion the dominant note has not been one of temperance. For example, as an illustration of the tendency of a good many writers to make extreme and extravagant statements in defending their position, I quote the words of a prominent eastern educator who says, in speaking of the relation of mathematics to physics, "Some physics teachers congratulate themselves when they have crowded out of their classes the great majority, and have left only the mathematically elect, and they avow it to be their purpose to kill enthusiasm wherever they find it." And again, the same writer in a recent number of SCHOOL SCIENCE AND MATHEMATICS says, in referring to the relation of certain college methods to college students, "These students have a starvation course in measurements called physics. Their tutors having just passed through the same course with excessive specialization are suspicious of that expansive thing called culture. They effect to despise not only the pub-

lic but all departments of learning other than their own. They surpass the theologians in narrowing down their lines of orthodoxy . . . their standards would outclass Davy, Faraday, Tyndall, Pasteur, Humbolt, Maxwell, Huxley, Agassiz, Cooke, Shaler and the like, for these men all preached the doctrine that science is good for culture and should be given to all." And then, as if to cap the climax, he continues, "The influence of the college in all departments, classical as well as scientific, is toward driving culture out of the schools."

This is a terrific indictment, and if it be true, we had better close up our colleges and quit teaching physics.

Again, in the third place, these discussions reveal the fact that physics teachers in general are entirely at sea as to what constitutes a fundamental method of procedure. When it comes to the three great pedagogical questions—the What, the When and the How of the subject, our leaders both in high school and college physics, seem to be able to agree on only one thing, *and that is that they disagree.* For example, one of the most prominent teachers of high school physics in my own state (Michigan) says in a pamphlet, "Let us understand at the outset that physics is not phenomenology." Then I turn to a recent number of the Educational Review and read the words of an equally prominent eastern teacher who says, "High school physics should be mainly phenomenology." One college professor said at a recent state meeting, "In the matter of individual laboratory work, I consider the *quantitative* exercise only as of value;" another, already quoted, refers to the quantitative exercise as a "starvation" course in physics. And again, a recent writer advocates a year's preliminary training in general science as a preparation of the regular course in physics. This is followed by another writer in the same journal who counters by saying, "I look upon this proposed preliminary course as a dangerous proposition." But these, you say, are isolated examples. I will give, then, one that is not an isolated example—one that may be considered a sort of concentrated extract of the general opinion with reference to fundamental methods in elementary physics. I refer to the recent report of the National Commission on the Teaching of Elementary Physics. This commission in summarizing the results of its labors—a work involving an enormous correspondence and including reports from teachers of high schools, normal schools, colleges, and universities of nearly every state in the Union—in Circular V makes the

following remarkable and extremely significant statement: "Thus far the only conclusion that can be drawn is that we teachers of physics are far from united *on any one point.*"

And finally, a definite, organized effort is now being made to bring order out of an apparent chaos of conflicting opinions. I have already referred to the National Commission on the Teaching of Elementary Physics.[1] This commission is composed at present of forty-eight members, chosen as representatives of twelve state and inter-state associations. Its object, as stated in Circular IV, is two-fold. "First, to find out just what is wanted by the teachers as a whole for the improvement of physics; and second, having found this out, to attempt to secure it for them." Its labors thus far have been confined mainly to the preparation and publication of a series of circulars bearing on a proposed new syllabus, the object of which is to reform, systematize, and unify prevailing methods of teaching elementary physics.

Personally, I am very much interested in this so called "New Movement," and in my judgment its most significant feature is the proposed syllabus. I do not look for great things from this source directly, for I think the syllabus is more of a symptom than a remedy, but indirectly it will no doubt play an important part in that it will serve as a bone of contention—that is to say, it will precipitate a row. The storm has long been gathering and is now ready to break, and if this syllabus should prove to be the means of clarifying the atmosphere, it will have served no small purpose.

So much then for the present situation. Let us now consider some of the causes which have brought it about. To read an account of the rise of high school physics to its present high and honorable position is to read very modern history indeed. So young is this member of our educational family that there are many today who can recall nearly every phase of its evolution. High school physics has passed through three distinct stages. It began as a study of the more pronounced phenomena of the outside world. These were the days of the old natural philosophy—phenomenology—beautifully typified by the famous "Fourteen Weeks" science series. Some no doubt, will recall the picture which appeared as a frontispiece in Steele's "Fourteen Weeks in Physics." It was a full page illustration of the leaning tower of

[1] C. R. Mann, Secy, University of Chicago.

Pisa and its environs. At the bottom of the page appeared the following account: "In the foreground stands the Leaning Tower. Next to this is the Cathedral. In front is the Baptistry, and back of the Baptistry, the Campo Santo, a cemetery containing sacred soil brought by the Crusaders from the Mount of Olives." Here is something that would delight some of our modern reformers. A course prefaced by such a combination of science and history and theology surely could not be well classified as a "starvation course in physics."

This phenomenology era was followed by what may be called the "inductive stage." Those were the days when the inductive method was the fad—both in the realms of science and out. Immature pupils were set to the business of rediscovering laws and manufacturing definitions. The seriousness with which these children went about this task was equaled only by the ingenuity they displayed in guessing before hand just what sort of a law was demanded, or what brand of definition was most acceptable. In this respect they did in elementary science precisely what they did in answer to the queries of the child study enthusiast of a few years ago—they gave as nearly as possible just what they thought was expected of them. They were interested to be sure, but in a good many instances it is to be feared that this interest was of the same brand as that of the small boy, who was noted for his inattention. One day his interest was aroused, however. He watched his teacher's face intently as she talked. At the close of the exercise she asked him what he had learned. He responded, "Teacher, your upper jaw hasn't moved once this afternoon."

The third stage followed, partly as a reaction from the methods just described, and partly as a natural consequence of the great impetus given to high school physics by the famous Report of the Committee of Ten. This report, together with the new standard of entrance requirements adopted by Harvard and other leading universities about this time, gave an enormous stimulus to the subject of elementary physics and at the same time did much to shape the policy of its methods up to the present day. In the Report of the Committee of Ten, three things were directly or indirectly emphasized. First, the value of physics as a high school study; second, the importance of the quantitative side of laboratory work; and third, the necessity of securing college trained teachers. Physics at once became one of the most important courses of the high school curriculum. The number of students pursuing this sub-

ject was large; teachers were enthusiastic; and laboratories and laboratory exercises grew and multiplied. The pendulum of favor in things that related to laboratory methods swung sharply from the purely qualitative exercises of the old school to the quantitative, of the new. Now, add to this the fact that a large number of the teachers of physics were fresh from college where their training in science had been dominated to a certain extent by mathematics and by quantitative methods, and it is not difficult to guess the direction given to elementary science teaching. Class room work became more and more strenuous; and the labaratory exercise daily demanded larger things of the pupil. In a word high school physics became more difficult than that presented by the majority of old time college courses.

Now I do not pretend to say that every teacher of elementary physics carried matters to such an extreme. There were teachers—many of them—who were not carried off thier feet by the wave of popularity which had swept their subject into such high public favor—teachers who tempered their teaching by moderation and good judgment. In speaking, however, of the general movement, one is forced admit that high school physics was not made a bed of roses upon which the incompetent or indolent could recline with ease. Elementary physics demanded serious consideration on the part of the pupil. No student began this course with the idea of having a play spell. It involved the learning of lessons, the working of problems, the doing of experiments, and the writing up of note books, and all this took time—a good deal of time. As a consequence, therefore, teachers of other subjects began to complain that physics was taking more than its share of the student's time. This complaint was not heeded at first by the physics teachers. Indeed it is a rare thing to find a case in which a teacher of any subject does heed such a complaint. The matter, however, did not rest here. Complaint began to come from another quarter, and the agitation, started by teachers of other high school subjects, began to assume more formidable proportions. Superintendents had been appealed to, but at first they were slow to act. Soon however, their sensitive ears became aware of a rumbling sound more fearful than that of faultfinding teachers—namely, the voice of protest of school patrons—parents whose sons and daughters—principally the latter, had found physics a stumbling block in the way of graduation honors. Now, if

there is one thing more than another that will "energize" a superintendent, it is the voice of protest of a belligerent parent, and this voice had become so pronounced that a good many of the aforesaid superintendents made haste to espouse the cause of those who were demanding a return to the good old days of easier lessons and qualitative exercises. I am not finding fault with the superintendents' attitude in this matter; neither am I trying to excuse the over enthusiastic teachers of physics. I am simply stating the facts.

At this stage of the agitation a new factor began to manifest itself—a factor hitherto unnoticed, and even today not fully appreciated. This was a force that has played, and if all signs fail not, is destined to play an important, though unfortunate, role in our educational scheme. I refer to the kindergarten movement. I hasten to say, before proceeding further, that I have no fault to find with the kindergarten movement as such, when confined to the kindergarten department. The kindergarten has proved a blessing to childhood. It has taken from the primary grades the lock-step discipline of the prison, and has substituted the discipline of love; it has taken away from the lower grades paralyzing inactivity, and has substituted directed work and joyous play.

Notwithstanding all this, however, the kindergarten has not probed an unmixed blessing. Before such be the case, two conditions must be imposed upon it. The first is that its administration be placed in the hands of skillful teachers—true kindergarteners; and the second, that its methods be confined within proper limits—and these limits, in my opinion, most emphatically do not include the high school. Up to the present, these conditions have not been realized. Kindergarten methods were at first confined to the primary department. They gradually worked upward through the intermediate grades, and today these same methods are beginning to manifest themselves in the high school. It is the opinion of an increasingly large number of teachers that our high school work shows unmistakable signs of this influence, both in the character of the instruction given and also in that of the product turned out. *The tendency of the times seems to be toward making everything interesting and easy for the child.* And it is significant to observe in this connection, what a large number of high school pupils have come to consider the terms *interesting* and *easy* as synonymous expressions. Now, no

one in his right senses will object to making a subject interesting, nor yet to making it reasonably easy—that is, as easy as the nature of the subject will permit; but, on the other hand, when it comes to trimming every subject, irrespective of its nature, with reference to making it *interesting* and *easy*, it is neither good pedagogy nor good sense.

It thus appears that this agitation is a resultant, so to speak, of several forces. It originated in a protest by teachers; it was augmented by the complaint of parents; and of late it has been mightily stimulated by the sweeping indictment of those disciples of Froebel who claim that high school physics is too difficult; that it lacks interest; and that it is devoid of culture value. Then to summarize further, the whole agitation is traceable to two causes First, faulty methods on the part of teachers of physics; and second, faulty ideals on the part of would be reformers.

Now comes the question of reform. Teachers of high school physics are today in a ferment. Some are loud in their demands for reform; others are equally strenuous in insisting that no reform is necessary. We must admit that "where there is so much smoke there must be some fire;" where there is so much agitation, there most be some exciting cause. That the prevailing methods of high school physics are above criticism, I do not claim; that they are altogether bad, I will not for a moment admit. In a certain sense physics, no doubt, needs reforming; this, however, is equally true of nearly every other subject. So long as the world moves, a continual readjustment of matters educational, as well as matters economical and political, will be necessary.

In all this business of reforming, however, it is important to keep in mind certain fundamental principles. We are by nature prone to rush to extremes. It has been said that the American possesses two notable characteristics. The first is the long suffering patience with which he endures intolerable conditions; and the second, is the headlong manner with which he goes about reform when once aroused. Therefore if reform in high school physics be necessary, let us go about it "decently and in order." And, to repeat, let us keep in mind that there are certain laws which should govern every reform. It is of these fundamental principles I now wish to speak.

In the first place, we should consider the *nature* of the subject to be reformed. All high school studies cannot be measured by

the same standard. Some are by their nature easy; some difficult. Algebra, for example, is not an easy subject; Latin is not an easy subject; and physics most assuredly is not an easy subject, and no amount of trimming or doctoring will ever make it an easy subject. Physics deals with the laws of the physical universe. These laws are as they are, and they cannot be changed to suit the whim of every passing faddist or would be reformer. Physics, to repeat, is not an easy subject; it is not an appropriate subject for the kindergarten. If it turns out that the mastery of its elementary laws and principles is too difficult for the modern high school pupil, then throw it out and substitute something easier—nature study, say; but in the name of truth let us call it "nature study" and not "physics." Some of our would be reformers would reform high school physics in the same way the man reformed his neighbor's dog. The dog in question had killed some sheep, and the owner of the sheep remonstrated with the owner of the dog, and as a result of the conference it was decided to punish—that is to reform, the dog by cutting off his tail. The man who had lost the sheep agreed to hold the dog by the tail while the owner wielded the axe. As the weapon descended, the man suddenly jerked the dog backward, ***and his tail was cut off just behind his ears.*** Thus would they deal with physics, if one may judge of future actions by certain present recommendations. They ask us to trim and trim until it would seem that nothing would be left that can be called physics. I repeat, in this matter of reform the nature of the subject demands consideration. If we are to teach physics, let it be physics.

But what is "Physics"? exclaim both conservative and radical. I am perfectly well aware that the key to the whole situation lies in our definition of physics. This whole question of reform hinges upon the interpretation put upon this word. Personally I have very definite ideas with regard to the meaning which should be attached to the word physics, as applied to a high school course. High school physics should concern itself primarily with a study of the fundamental laws of the subject. These laws should furnish the skeleton—the framework of the course. Round out the structure with important facts; ornament it, if you please, with interesting illustrations; show the relation of part to part by means of the mathematical equation; get it into the experience of the student by means of labora-

tory work. But after all, let us not forget that the law is the importnat thing. Not that the mere learning and reciting of laws is of any great importance. The value lies in the mastery of the law—in the acquisition of a "realizing sense" of its significance. A student's head may be full of facts and illustrations and, other things, yet he may know very little physics. When he is confronted with a question concerning physics, his attitude of mind should not lead him to inquire, "Where have I seen an answer to this question?" but rather, "What physical law governs the case?"

The laws of elementary physics are not so numerous as to seriously burden the student of average ability. Some of them are interesting and some are uninteresting, depending a good deal on the experience and view point of the pupil. Nevertheless, interesting or not, the student who has completed a course in elementary physics should be acquainted with these fundamental laws and principles; he should know their meaning and their application to the ordinary affairs of life. This, then, to repeat, is my personal notion of the nature and function of the high school physics. Let us make it as interesting as possible; let us make it as easy as possible, but let us not sacrifice the subject merely for the sake of making it easy—for the sake of conforming to the general tendency of the day which demands that everything be made easy.

Now this whole question of making physics easy centers about two points—the first is the use of the mathematical equation in elementary physics; and the second is the quantitative exercise in laboratory work.

I am not an extremest with respect to these two factors. I have never been in the habit of taking off my hat whenever a mathematical equation, for example, presented itself. I think that in some cases too much has been made of the mathematical equation. Some teachers of elementary physics have carried its use to an extreme. But is the fact that a few teachers have misused the equation a sound argument for throwing it out altogether? I know of no method of showing the relationship of one physical quantity to another that is so elegant and so usable as this same much abused mathematical equation. If we can represent, for instance, the relation of force to mass and acceleration, or any other set of relations, by the use of a simple mathematical equation, let us by all means have it, for surely no better opportunity will ever

come to the high school student for learning the real significance of the mathematical equation than that presented by the simple equations of elementary physics.

And what I have just said with respect to the use of mathematics in elementary physics, applies in a general way to that other disturber of the peace—the *quantitative* exercise. What oceans of ink have been spilt in discussing the relative merits of qualitative and quantitative laboratory work. The fact is that both forms of exercise have much to commend them; yet neither is perfect.

The qualitative exercise, for example, presents the subject to the student "in the large;" it appeals to his imagination; it arouses his interest. Hence the wise teacher will make use of this form of exercise, to a certain extent. It does not follow, however, that he should adopt it to the exclusion of all other methods. Every experienced teacher knows how readily the purely qualitative exercise degenerates into mere entertainment, in which the pupil fritters away his time in playing at laboratory work.

On the other hand the quantitative exercise can easily be made too strenuous and too exacting for high school pupils. Perhaps in no other department of elementary physics have matters been carried to such an extreme by over enthusiastic instructors, as in this particular line. Yet this does not offer a valid argument that the quantitative exercise should be discarded. As in the case of the mathematical equation, elimination would not necessarily mean reform. While I have no patience with those teachers who speak of quantitative work as if there were something sacred about it, yet I am persuaded that the backbone of a laboratory course should consist of just such work. For giving point, and direction, and definiteness to laboratory work I know of nothing so valuable as an exercise involving some sort of a measurement.

I find by actual investigation that our most successful teachers of high school physics are using *both* methods. They are adopting from each that which best suits the particular needs of their classes and the conditions under which they work.

And in this connection it will be pertinent to say that what high school physics needs today more than reformed methods, and reformed texts, and reformed manuals is the competent teacher—the teacher who has academic training and native common sense. These teachers who bring discredit upon physics belong to three

classes. First, the teacher who attempts to use university methods with high school pupils; second, the teacher who doesn't know his subject; and third, the teacher who thinks he knows it all. From these three abominations may our schools be delivered, and especially from the last. Colonel Parker was entirely right when he said that the nearest approximation to absolute rest in the universe is the mind of the teacher who has *the* method and is content therewith.

And as a last word with respect to proposed reforms, I speak of the child—make a plea for the child. Let us never forget that all the vast and complex machinery of our school system exists not for the glorification of the teacher, but exists for the child; and if it is true that the tendency of our schools and colleges is to crush out enthusiasm and destroy culture then in Heaven's name let us close our schools. I for one, however, do not believe that the indictment is true. I will admit that there is much in our methods that is not above reproach—large opportunity for reform, for improvement. I also think that the modern child is in danger—in a few cases in danger from over work, but in the great majority of cases from *overindulgence.* I have already referred to the tendency to adopt kindergarten methods in the high school, and this is the overindulgence to which I refer. I have absolutely no patience with the spirit of the modern little Adam who comes to a dead stop in the procession the moment a difficulty presents itself—who refuses to move if the way is not made easy and the topic interesting. I have not forgotten my subject, high school physics. What if physics is not all interesting and easy? What if it does take some self control to master its laws? This is just what the modern child needs. Physics, of all subjects of the high school course, is best suited, because of its very nature, to give mental backbone. The function of an education is three fold: *To increase knowledge; to enrich experience; to give control.* That physics gives the first two, no one will deny; and that it is preeminently fitted to give the last—self control, I am sure all will agree. The quality that young America most lacks today, hence most needs, is self control—that control which will enable him to face up to and master a proposition whether it is to his liking or no. Has it ever occurred to you that 74 per cent. of all the men who today hold prominent and important positions in this country came from the farm. Not from the city with its magnificent

schools, but from the farm. What is there about the farm that makes masterly men? Is it the clear sky and the song of birds, and all of that? The success of the farm boy comes from the magnificent self control—the self mastery, which farm life gives—the ability to work hard and persistently at a task whether he likes it or not. There may be other factors—no doubt there are, but self control is the key that opens to the country boy the doors of success. And this is one of the great lessons that our schools should teach—the lesson of self mastery, and I repeat, it is one of the qualities that high school physics is preeminently fitted to give, provided we do not reform it beyond recognition or possible use.

THEORIES OF BIRD MIGRATION.

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(*Continued from the April number.*)

The Homesick Theory Another attempt at an explanation is based upon the fact that in the spring migration birds are returning home to the place where they were born. May it not be then that they are overtaken by a strong desire to revisit their birthplace as the changing seasons duplicate the climatic conditions which existed when they formerly dwelt there? May they not be driven by a kind of home-sickness to fly north to the scenes of their early life? This is a favorite theory with those who are accustomed to endow birds with semi-human attributes upon a sentimental rather than upon any anatomical basis. The theory suffers somewhat when it is remembered that most birds forsake the home they make such strenuous endeavor to revisit, the moment their nesting duties will allow which would hardly be expected if they possessed such an overmastering affection for a particular locality as the homesick theory implies.

The Desire to Disperse Theory Again, to say that birds have a "desire to disperse" in the spring of the year, as Dixon suggests, simply begs the question as to what actually causes the dispersal.

The Nestling Food Theory Alfred Russel Wallace, whose biological opinions are certainly entitled to respect, points out that the food upon which many nestlings are fed consists of soft bodied insects and other materials that become relatively rare

in the tropics during the dry season. It is so customary to think of the tropics as a region continually teeming with all sorts of life that testimony to the contrary by one who has spent many years there, comes at first as a surprise. It is, however, undoubtedly true that food of a quality suitable for nestlings would not be present in sufficient quantity if all the migratory species remained there to nest. Consequently in this sense, the spring migration may primarily depend upon food supply. Omnivorous birds whose food supply is to a lesser extent affected by the changing seasons, migrate less than those who feed upon a restricted diet.

The Safe Nesting Site Theory Another theory has been presented by Professor Brooks of Johns Hopkins University, namely, that birds go north in the spring in order to find safer nesting sites than are available in the over populated tropics. It is natural that all animals during the breeding season should seek retirement and a place of security in which to rear their young and this seems to be the universal rule among all those animals which in any active way care for their offspring. But is it a fact that there are more safe nesting sites in the north than in the tropics? Surely in the luxuriant tropical vegetation there are more nooks for concealment, acre for acre, than in our open northern forests! In both regions only a small number of the sites available for nesting are utilized. If the reason for nesting in the north was for increased safety it would be expected that those birds which do remain behind to contend with the perils of tropical nesting, would develop greater skill in building nests inaccessible to enemies than those going north who would presumably be exposed to fewer perils. Such, however, is by no means the case. Tropical nests cannot be distinguished from northern nests by any such criterion of efficiency against enemies. Some of our best nest builders, the Baltimore Oriole for example, are also notable migrants. In the case of both of these latter theories it would seem as if Nature, who always works along the lines of least resistance, would have found it easier to adapt migrating birds to a different sort of nestling food or to perfect in them the skill necessary to build securer nests in the tropics before evolving the intricate machinery incident to annual migration.

The Vacuum Theory A theory proposed by Allen seems more reasonable. It rests upon the idea that "Nature abhors a vacuum" and, therefore, any accessible territory from which animals have been temporarily excluded will not long re-

main unpopulated after the cause of temporary banishment has been removed. During the winter birds are forced to abandon the northern latitudes for the tropics because of cold and the consequent shortage of food. When spring comes this entire vacated area is again thrown open for habitation at the very time when the birds, temporarily crowded into the tropics, are beginning to seek nesting places. It is quite as inconceivable to imagine that birds, with their active powers of flight, should fail to reinvade the territory, from which they had been temporarily driven by winter, as soon as it is again available for habitation, as that an expansible gas should remain in a flask after the stopper which confined it there had been removed. This theory, then, explains spring migration as a logical expansion consequent upon the compression into the tropics during winter of a large per cent. of the bird population of all latitudes.

The Over-population Theory

Another factor has been emphasized by Taverner. This may be called the over population theory depending as it does upon the circumstance that whenever the breeding season opens there is suddenly a great increase in population within a given feeding area. Such a condition must result in a keener competition for food and those birds who are stronger or who are the earliest to mate and produce young drive out the weaker and tardier ones into the surrounding region. This dispersion would not be towards the south, neither toward the east nor the west, because in all these directions the territory would be equally preempted, but rather toward the north where there are fewer birds. Thus migration from the tropics might have had its origin. The direct result of such a movement would be that those individuals that were forced to become explorers in search of an adequate food supply would come to a hait only when compelled to do so by lack of food or when harrassed by superior competitors or, finally, by the demands of that period in their life cycle when the physiological impulse to nest-building can be no longer delayed.

Taverner explains the fall migration in the same way. That is, an overpopulation occurs in the nesting region at the north. The old birds drive away the young ones, or the first nestlings to mature become better established than those hatched later, driving the latter out. These being thus forced to migrate, on account of unfavorable conditions in the north find relief only by moving south and this constitutes the fall migration. This theory as-

sumes that it is among weaker birds, those unable to hold their own, that the wonderful and complex habit of migration has developed, a habit demanding apparently far greater qualities of courage, persistence and resourcefulness than would be required by competition for a livelihood with their fellows in a neighborhood already familiar to them.

Ancestral-Habit Theories All of the theories thus far mentioned to explain migration, namely, instinct, homesickness, dispersal, quality-of-nestling food, safe nesting sites, vacuum and overpopulation, seek to find an explanation in factors now operative. It is possible that a key to the puzzle may be found by regarding the performance as an inheritance of habit whose origin depends upon factors which have now ceased to act.

Gräser's Theory One of the most recent theories embracing this point of view was proposed in Germany by Gräser in 1904 and is based upon the supposition that the ancestors of modern birds, living in Tertiary times were very vigorous flyers who passed freely from one Tertiary island to another across immense stretches of water in order to find food and nesting sites. As the widespread tropical environment of the Tertiary times gave place to modern climatic conditions with changing seasons, and, as the present distribution of land and water gradually developed from the immense Tertiary seas with their numerous islands, birds more and more found suitable conditions of life in restricted areas wandering less and less until finally these ancestral wanderings have become limited to the regular fall and spring migrations, while many species are practically stationary. The logical conclusion of Gräser's theory is that birds are constantly becoming less migratory and in time will become so well adapted to local conditions that migration will cease. This bold conception of the case loses significance when it is remembered that all the evidence from embryology, comparative anatomy and palaeontology points unmistakably to the conclusion that birds have arisen from reptile-like ancestors of the crawling or lizard type and not from the flying or pterodactyl type, and, moreover, that the art of flying was a gradual acquisition which had by no means reached the perfection in Tertiary times which Gräser's theory presupposes.

The Deichler-Jäger Theory Another ancestral-habit theory, known as the Deichler-Jäger theory after its proposers, lays particular emphasis upon the rôle played by the glacial period toward the end of Tertiary times. There is geological evidence

that during the pleistocene period at least three distinct glacial ages occurred one after the other, during which the present temperate regions of the earth were slowly invaded by an encroaching polar sheet of ice until they became quite uninhabitable except by arctic organisms. Before and between these glacial ages modern temperate regions swung to the tropical extreme in character which is proven by the discovery of fossil ferns as far north as Greenland. The Deichler-Jäger theory assumes that birds as a class in all probability arose from reptile-like ancestors during Tertiary times and that their original home was in the north. So long as the climate remained essentially tropical throughout the year there was no occasion for deserting this area. With the gradual advent of the first glacial age, however, the climate of the north slowly changed from being tropical the year around to a condition of seasonal changes somewhat similar to that obtaining today. When these seasonal changes became extreme tropical conditions were interrupted and the first winter occurred. There is no reason to believe that this first winter was either sudden or severe but, in the course of time, it became an established annual occurrence and was finally much more severe than our winters at present, as has been demonstrated by the occurrence of fossil reindeer bones in France and arctic musk-oxen as far south as Kentucky.

Now when organisms of any locality are overtaken by winter one of these results may occur; first, they may simply perish; second, they may hibernate through the cold weather in a semi-torpid condition, or finally, they may migrate to a more favorable environment. Birds, being endowed with the power of locomotion through the air pursued the latter alternative and thus the fall migration had its origin. Every spring as the advance of the glacial sheet relaxed for a season the birds which had been driven south into crowded quarters by the rigors of winter temporarily reoccupied the ground they had lost, and these annual oscillations becoming greater and greater as the glacial age gradually gave way to an interglacial or post-glacial age, the conditions of migration which we observe today became established by long repeated practice.

The Dixon-Braun Theory A third ancestral-habit theory was developed independently in 1900 by Braun, who observed migrating birds extensively for several years in Constantinople and in 1892 by the English ornithologist, Dixon. The Dixon-

Braun theory postulates that the center of distribution of birds, that is, their original home as a class, was not in the north as the Deichler-Jäger theory assumes, but in the tropics. The reason for this conclusion lies in the fact that many genera of our migratory birds are most largely represented by tropical species which do not migrate at all. For example, there are many more species of flycatchers remaining throughout the year in the tropics than migrating north, indicating that the original distribution-center from which flycatchers in general have spread must have been in the tropics where they are now most at home. As a result of overpopulation or famine in times past these tropical birds have been forced to travel to less crowded and more favorable localities for food. Relief could be found only toward the north since overpopulation is most likely to occur during the spring breeding season at a time when the northland is just released from the rigors of winter. Thus, according to the Dixon-Braun theory the first migration was a spring migration while according to the Deichler-Jäger theory the first migration was a fall migration. The Dixon-Braun theory further supposes that the original spring migrants, having been forced north by over-population are in turn compelled as winter comes on to retreat south into the overcrowded tropics or perish, only to repeat the experiment of finding relief in the north as soon as the advent of spring allows. In this way the old birds perform again what in their experience had proved to be a successful experiment, while the young birds go along with them and learn the habit.

The Kobelt-Duncker Theory A recent attempt has been made by Duncker in Bresslau (1905) to combine elements of the two theories last mentioned. Duncker accepts the classification of birds made by Kobelt (1902) into *summer-excursionists* (Sommerfrischler) and *winter-wanderers* (Winter fluchter). The former are birds whose home was originally in the south but who now make an annual excursion (Badereise!) north in order to breed returning home again as soon as this function is accomplished, while the latter comprise those whose home was always in the north and who are temporarily driven abroad in the fall by stress of temperature and lack of food, only to return home again as soon as physical conditions allow. The summer excursionists go into a foreign land far away from their ancestral home or point of origin as a species, to perform the highest act of their lives, that

is, the production of offspring. The winter-wanderers breed, as good conservatives should do, upon their ancestral acres but are obliged to be wanderers therefrom during many months of the year.

The Marek Theory In the Ornithologisches Jahrbuch for 1906 there appeared still another theory to explain why birds migrate. It was put forward by Professor Marek of Hungary and emphasizes the factor of barometric pressure as being of the greatest importance in determining the migratory movements of birds. Marek's conclusions are entitled to serious consideration for they are based upon many years of painstaking investigations concerning the correlation between bird migration and barometric conditions. He began by comparing known migrations of the woodcock in Europe with the weather charts of the same dates and found that, aside from minor deviations, these birds migrate from anti-cyclonic areas of high barometric pressure to cyclonic areas of low barometric pressure. This coincides in general with the direction of the wind but Marek would not say that it is the wind which causes the movements of birds,—rather that both wind and migration are caused by the same conditions, namely, the proximity of two areas of unequal barometric pressure. During the winter the polar regions form an anti-cyclonic area of high barometric pressure with low temperature and clear air relatively free from moisture while in the tropics there is a corresponding area of low barometric pressure with high temperature and much humidity. The prevailing winds are from the north because the air always flows "down hill" from high pressure areas to those of low pressure. When spring comes there is a relative shifting in position in the barometric maxima and minima. In the north the temperature rises, humidity, cloudiness and precipitation all increase and an area of low barometric pressure becomes gradually established while the reverse conditions are occurring in the south. The result is that southerly winds become the prevailing ones and, at the same time, birds who are extremely sensitive to barometric changes unconsciously begin their spring migration. In the same way the fall migration is initiated by the shifting of the barometric maxima and minima.

Irregularities in migration, such as remarkable flights of birds and unusual delays in the migration movement are all directly traceable to the barometric conditions prevailing at the time.

Marek's observations begun upon the woodcock were extended to very many other species. In fact, the paper referred to is a summary and generalization of 43 papers bearing upon migration, which this industrious investigator has published. It must be admitted that Marek's theory has the great advantage of dealing with known factors which may be made the object of further investigation. From his point of view there is no necessity for referring the habit of migration to hypothetical ancestral behavior, nor for endowing birds with such human attributes as love of home or the memory of previous successes. The streaming northward of birds in the spring and their return southward in the fall are both primarily dependent upon the same observable external factors as those which cause the flow of the air in the form of prevailing winds, northward in the spring and southward in the fall.

Conclusion

Yet the riddle has by no means been solved. There still remains an immense halo of mystery around bird migration because there are so many things we do not know. We not only do not know *why* birds migrate but as yet we do not know *how* they migrate except in a general way.

What becomes, for instance, of the swallows, has been a conundrum for 2,000 years. Aristotle thought that swallows passed the winter buried in mud or in the bottom of ponds. Linné credited the hibernation idea. Dear old Gilbert White, in spite of his observing eye, died in doubt. Finally, a few decades ago an Italian naturalist thought it worth while to submerge a few swallows under water to see how long they would survive. These feathered martyrs to science of course promptly died, and thus at least there was delivered the death blow to the hibernation-under-water theory, but to this day no one knows the complete migratory route of the swallows nor where they pass the winter. Mr. Wells W. Cooke, our American authority upon bird migration, writes: "Upon leaving the Gulf of Mexico did they drop into the water and hibernate in the mud as was believed of old, their obliteration could not be more complete."

The meagerness of our knowledge concerning the migration of swallows is repeated to a large extent in the case of almost every other species when we seriously attempt to winnow out fact from fancy. It may, therefore, be said in conclusion that, until the store of facts as to how birds migrate has been greatly increased, we can only delight ourselves with interesting speculations as to *why* birds migrate, acknowledging the problem unsolved.

PHYSICS IN SECONDARY SCHOOLS.

By David C. Caldwell,
Manual Training High School, Louisville, Ky.

In the early part of the present school year, I sent out printed forms to ninety-two of the leading high schools of this country, asking that they be filled in and returned. These forms contained ten questions dealing strictly with the teaching of physics in secondary schools. I have received seventy-four replies, and feeling that this is of interest to every teacher of physics, I give the results obtained.

1. What time is given to the study of physics?

There were fifty-one schools where physics is taught one year; twenty-one where at least one and one-half years are given; and in some cases two years are required.

2. In what year is physics taken up?

In the fifty-one schools where physics is taught only one year, only three take it up at the beginning of the second year, thirty-seven take it up during the third year, but in twelve of these it is optional whether they take it up in the third or fourth years; in five schools it is taken up during the senior year only, and in the rest it is started in the second half of the second year and continues through the first half of the third year. In those schools which give more time to physics, there seems to be a tendency to give an elementary course in science the first year and then physics in the third and chemistry in the fourth year. In eight schools they give three half years to physics.

3 and 4. Division of time for class and laboratory.

The general division of time seems to be one period of forty-five minutes for demonstration; two periods of forty-five minutes each for recitation; and two periods of ninety minutes each for laboratory work. This seems to be the least amount of time commensurate with the amount of work which should be done. One plan was used which might be profitable where the teacher was allowed two single periods and three double periods per week, to be used as he saw fit.

5. In matters of text-books the Carhart and Chute and Millikan and Gale seem to have preference. In two schools they use Higgins for an elementary course in the first year and Millikan and Gale for the regular physics work in the third year.

6. As regards texts for laboratory:

By far the majority of the schools use the teacher's manuscript with such books as Chute; Chester, Dean, and Timmerman; Nichols, Smith, and Turton; Adams, and Millikan and Gale, for ready reference. I personally find Adams Laboratory Manual a very available book, but the use of a manual in a laboratory must be determined by the apparatus at hand.

7. How many students in the laboratory?

The general opinion is that from 16 to 20 is the proper number, unless there is an assistant to help. Personally I think that twelve (12) would be a better number, in that the teacher can give more personal attention to the manipulation of the apparatus.

8. As to the number of experiments going on at one time.

When apparatus will permit, it is eminently more satisfactory for all to work on the same experiment, but with twenty boys we might successfully divide them into four sections, each section working on the same experiment, but each boy having his own set of apparatus. With just the four different experiments the instructor can give more instruction and time to each section and thus accomplish much more satisfactory work.

9. The number of experiments which each boy should have should not be less than thirty but some colleges require more.

10. The tenth question was as regards surveying. Of the seventy-four replies received, only ten reported as having surveying, and six of these only slightly in connection with the trigonometry. I raise the question, Is surveying a high school subject?

PHYSICS CLUB OF NEW YORK.

The Physics Club of New York at its regular meeting held March 7, 1908, unanimously adopted the following resolution:

Resolved, That a uniform course in Physics for all schools is both undesirable and unattainable. We therefore recommend:

1. That syllabuses should deal with the barest outline of general principles, leaving each teacher free to fill up the course according to his best judgment.

2. That examinations for college entrance should be confined to the general principles specified in the syllabus and that a teacher's certificate should be accepted for other material—this might well take the form of a rather full statement of the work done.

A SYMPOSIUM ON THE TEACHING OF BIOLOGY AND NATURE STUDY IN NORMAL SCHOOLS.

By B. L. Seawell,

State Normal School, Warrensburg, Mo.

Having heard two criticisms on my work as a teacher of biology in the Warrensburg, Mo., Normal School (doubtless among the many I have not heard) I decided to profit by them if possible. One of these criticisms charged that my courses were "too strictly scientific," and the other, that I offered no course in nature study.

That I might offer courses in keeping with the general spirit of the times in normal school education, I thought it might be well to learn if possible what other teachers in normal schools were offering. I promised myself that if all the others agreed in some policy different from mine, that I would adjust myself to the universal custom. As you will see, the doctors disagree, which leaves me entirely free, at least to be—"on the fence." I really think that at least one of the wholesome lessons we may learn from this symposium, is to grant the charity of our tolerance to others, since they certainly have as much right to their erroneous (?) opinion as we have to our correct (?) one.

The first step in collecting the symposium was to send out sixty-nine circular letters to teachers of the biological sciences in the normal schools chiefly of the middle West. The following questions were embodied in that letter, from the answers to which I hoped to learn if my own practices were widely at variance with others:

1. Approximately what percentage of students taking your courses afterward teach in High Schools and lower grades respectively?
2. Do you give courses in Botany and Zoölogy separately, or under the name of Biology? Does your judgment agree with your practice in this?
3. What portion of your course is given to the study of microscopic animals and plants?
4. What emphasis do you place upon ecological studies in the field?
5. Do you give a particular part of your course to physiological studies, or do you blend such studies with studies of structure?
6. Do you study type forms of each of the great groups of animals and plants, including marine types, or limit your studies to such organisms as may be collected in your vicinity?
7. Do you proceed from a study of the lower to the higher types, or make your course conform to seasonal conveniences and local forms?

8. Do you believe it more profitable for students who afterward teach in grades lower than the High School to have a course in random Nature Study of local faunas and floras, or a course in strictly systematic Biology involving strictly scientific studies?

9. Should a special course be offered in Normal Schools for those who may desire to become fitted for teaching Biology in High Schools?

10. Should any advanced and more technical courses be offered in Normal Schools?

Only forty-two answers were received, and I now offer a brief summary of these answers.

Question 1, Relative to Percentage of Students Afterward Teaching in High Schools:

The estimates vary with the conditions in the respective states as well as with the judgments of those giving estimates. Seven place the estimate above 10% afterward teaching in the high schools, and fifteen either make no estimate or place it at zero percent. The others range from 2% to 10%, most of them placing it at 10%. The highest, taken from actual records of the Peabody Teachers' College, Nashville, Tenn., is 43%. Greeley, Colo., estimates 15%; Natchitoches, La., 15%; Denton, Tex., 25%; Peru, Neb., 25%; Terre Haute, Ind., 33 1/3%; and Normal, Ill., 40%.

Those estimating that 10% of their classes afterward teach in high schools are Buffalo, N. Y.; Brockport, N. Y.; Stevens Point, Wis.; Macomb, Ill.; Emporia, Kan.; DeKalb, Ill.; Carbondale, Ill.; and Springfield, Mo.

Those estimating from 2% to 5% are Trenton, N. J.; Cedar Falls, Iowa; Bridgewater, Mass.; Las Vegas, N. Mex.; Mankato, Minn.; Milwaukee, Wis.; Westchester, Pa.; and Charleston, Ill.

Those estimating that none or very few afterward teach in high schools are Worcester, Mass.; Baltimore, Md.; Moorhead, Minn.; Castleton, Vt.; Cheney, Wash.; Chicago Normal; Winona, Minn.; Greensboro, N. C.; Cleveland Normal; Mayville, N. Dak.; and Duluth, Minn.

Seven failed to make an estimate. While these estimates are of little real statistical value they serve to indicate the diversity of conditions that prevail in the different states and normal schools relative to the employment of normal school graduates in the high schools, it being the policy in some states to employ college and university graduates only in their high schools, while

other states use normal school graduates, and have normals that offer courses fitting for high school teaching. It is obbious that if normal schools will not offer courses preparing teachers to teach in high schools, then high schools must look to the colleges and universities to supply their teachers.

Question 2, Relative to Names of Courses:

In response to this question I find that thirty-one of the forty-two offer botany and zoölogy separately, and only two, Los Angeles and Chicago, offer all the work under the name of biology. Emporia, Charleston, Springfield, Las Vegas and De-Kalb offer courses named biology, botany and zoölogy. Greensboro, N. C., offers one course named biology and one named botany. Baltimore, Md., offers botany and zoölogy separately in the "preparatory and high school departments," but together under the name of nature study in the "normal and professional departments." Jacksonville, Ala., reports, "Am sorry that that department is not organized." Bridgewater, Mass., reports that "pupils taking the regular course, four years, have botany and zoölogy given separately. Pupils taking the elementary course, two years, are given zoölogy." Cleveland Normal School reports, "We have no formal courses in botany, zoölogy nor biology. In our study of nature we use a glass with a broad field. Our students have had the formal side of botany and zoölogy in the city high schools. We try to bring them into closer sympathy with nature." Mississippi Central Normal, Walnut Grove. Miss., reports, "Practically no biological work is done." Geneseo. N. Y., reports, "We give a course in biology following in the main the state syllabus," while Brockport, N. Y., reports, "Since the adoption of the new course of study for normal schools in this state, no science is taught—the work being entirely professional." Evidently the New York teachers in normal schools do not interpret the state syllabus alike.

In the light of all the information gathered on this point I think it wisest to conclude like the teacher who was questioned as to whether he taught that the earth is flat or round, when he answered that he taught it either round or flat as the circumstances may require.

Question 3, Relative to the Study of Microscopic Animals and Plants:

Verily tastes do differ as to the use of the microscope. Those giving 50% or more of the course to microscopic animals and

plants: Charleston, 60% in botany; Denton, 33 1/3%; Geneseo, 33 1/3%; and Greensborough, 60%. Those giving 20% to 30%: Los Angeles, 25%; Charleston, 20% in zoölogy and 25% in botany; Emporia, 25%; DeKalb, 20%; Mankato, 25%; Peabody College for Teachers, 25% in botany but little in zoölogy; Stevens Point, 20% in botany, and Terre Haute, 20% in botany.

Those giving 10% to 20%: Chicago Normal. 10%; St. Cloud, 10%; Peru, 11%; Natchitoches, 12½%; Cheney, 12½%; Stevens Point, 10% in zoölogy; De Kalb, 10%; Cedar Falls, 12½%.

Those giving less than 10% or very indefinite: Kirksville, 6%; Baltimore, 5% in nature study; Las Vegas, "not much;" Springfield, "not much, mostly lens work;" Ypsilanti, "some courses largely microscopic, others not;" Westchester, "fair amount with micro-lantern; Mayville, "little in zoölogy, one term in botany;" Carbondale, "more or less throughout course;" Normal, "entire course in botany, several days in zoölogy;" Milwaukee, "protozoa, cœlenterata, algae, fungi and elsewhere as necessary;" Winona, "practically none;" Huntington, "Will have to organize the department;" Brigewater, "We use microscopic animals and plants when nothing else will serve our purpose;" Moorhead, "As much as will make, as nearly as possible, a well rounded course;" Duluth, "Almost none. In visiting normal schools in Germany last year, I found that they were not equipped with microscopes. Their biology was nature study training;" Castleton, "Very little—enough to know the cell;" Greeley, "Special courses to those who elect;" Buffalo, "Very little;" Trenton, "I use the microscope much less than I did ten or twenty years ago. I try to educate students to use their eyes aided only by magnifying glasses. When but a small percentage of our physicians use that complicated tool—the compound microscope—in the successful investigation of disease, we should not expect the students in their brief course in science to master this instrument, and own and use one afterward;" Worcester, "We do absolutely nothing with microscopic animals and plants."

Question 4, Relative to the Emphasis Given Ecological Studies.

While ecological studies have proven a widespread fashion, it has not proven an indispensable line of study on the part of some of our teachers of biological science in normal schools.

Those who do nothing or very little: Chicago, Natchitoches, Mayville, Carbondale, Mankato, Normal, Peabody, Cleveland,

Castleton, Walnut Grove, Brockport, Jacksonville, and several others that "explain it away" in some manner.

Those that give ecology great emphasis, or "the greatest," or "much," or "considerable," or regard it as "very important": Springfield, Emporia, De Kalb, Charleston, Ypsilanti, St. Cloud, Westchester, Winona, Huntington, Geneseo, Terre Haute, McComb, Buffalo, Cedar Falls, and Greeley.

Those that make favorable comment, or "explain it away" with excuses: Los Angeles, "All possible;" Las Vegas, "Field work supplements class work;" Peru, "Field work consists in collecting insects and dissecting material;" Kirksville, "As much as we can;" Mankato, "We make field trips and touch on ecology;" Cheney, "Each student is given an ecological problem to work out and report;" Milwaukee, "It is mainly impractical as a definite line of serious work;" Trenton, "I try to get all my students to do field work;" Denton, "Very little on account of lack of time;" Stevens Point, "As much as possible, which is small;" Terre Haute, "As much as possible, which is considerable;" Bridgewater, "Have more of the field brought to them than should be;" Greenboro, "Time and material being limited little work can be done;" Worcester, "Very little time can be given to field work;" Duluth, "We study insects and birds in the field;" Moorhead, "Believe in it but climate prevents;" Baltimore, "Believe it important—three to six times."

The foregoing diversity of opinion and practice indicates that whatever position one may take on the subject, there will be others who will quite agree. We may also "read between the lines" and learn that teachers of biology have a characteristic human weakness which leads them to emphasize those lines of study in which they are personally most interested, and about which they know the most. The subjects *we* have studied most are of paramount interest and importance.

Question 5, Relative to the Blending of Physiological and Structural Studies.

This question was answered almost unanimously in favor of blending the two lines of study. Only Buffalo claims to offer a course in physiological studies separate. Terre Haute gives one term in plant physiology to students having had a year in general biology. Huntington states that he expects to give a particular part of his course to physiology. Denton says, "Mainly physi-

ology, only sufficient of structure to make them understand the physiology." A course which would make us *understand* (?) the physiology would certainly be desirable.

Question 6, Relative to "Types," Including Marine Forms:

Twenty-eight study types of each of the great groups, including marine forms. Six definitely state that they study local forms only, and eight are indefinite. Las Vegas says, "We study as many type forms as possible;" Huntington, "I expect to be limited for a year or two;" Baltimore, "My studies are chiefly limited to the types of paramount interest to the economic life of the people of the state;" Buffalo, "We follow the syllabus of the New York Educational Department;" Trenton puts in a strong plea for the study of local forms in the following paragraph: "No course in any normal school with which I am acquainted is long enough to include all classes of plants or animals in its study. So I take the important classes of the vicinity for my work, and never send for 'types.' I knew a teacher in Minnesota to send, at great expense, for oysters for a lesson on that mollusk. He had unios in great abundance, which are by far more typical of bivalves. They could have been studied externally and internally, living and dead, ecologically and physiologically without cost. I have taught in summer schools in eighteen localities of twelve states—along ocean shores—in mountains—on prairies, etc., from Massachusetts to Texas, and I never found a place but had 'types' enough and to spare."

Evidently we must all agree that sufficient types are available in any vicinity to instruct a class in any normal school course, but no one would be content with a normal school course in history, including only the history of the county in which the building may be located, and none will deny that a lion is as interesting as a cat, and a starfish as profitable to know as a katydid.

Question 7, Relative to Procedure from Lower to Higher Types:

According to the reports the teachers divide nearly even on this disputed point. Thirteen state that they proceed from lower to higher types, regardless to the seasonal conveniences and local forms, and fourteen say that they are guided in their courses entirely by considering local forms and seasonal conveniences. Six state that the general trend of their course is from lower to higher types, but varied at times to suit the availability of ma-

terial at certain seasons. One reports that he proceeds from lower to higher forms in the study of plants, but varies from this plan in the study of insects before the lower types because of seasonal convenience. One writes that in his lower courses he makes no effort at systematic procedure, while in his higher course he adheres to the method of procedure from the lower to the higher forms. Emporia writes, "We study types—known, vertebrata, to unknown, protozoa: systematic zoölogy—simple, protozoa, to complex, vertebrata." I interpret this to mean that in observation work he proceeds from higher to lower types, and in lecture work he proceeds from lower to higher. Kirksville, "Sometimes I go from protozoa to man, other times from man to protozoa. One year I used arthropods for fall term, vertebrates for winter term, and the remaining branches for the spring term"—a fine example of "any old way." Five report so indefinitely that I cannot determine their plan. It is fortunate that the study of animals and plants is interesting in any order, and from any standpoint of consideration, and it would seem to matter little either to the student or the animal as to the order of procedure. Both the instrument and the hearers are likely to be less sensitive to discord than the musical performer.

Question 8, Relative to the Greater Profit to Grade Teachers, a Course in Random Nature Study, or Systematic, Scientific Biological Studies:

Twelve reports were so indefinite that I cannot interpret them. Trenton, Greeley, Denton, Ypsilanti, and Los Angeles make definite statements to the effect that they prefer random nature study for grade teachers, while Huntington, Greensboro, Stevens Point, St. Cloud, and Kirksville express a decided preference for the systematic and scientific study. Kirksville is perhaps most pronounced when he says, "Teach them botany, zoölogy, physical geography and agriculture, and they will take care of the 'blank-y-ty blank' nature stuff." Bridgewater, Mayville, Natchitoches, Mankato, Geneseo, and Peru offer courses in nature study in addition to their more scientific courses in botany and zoölogy, while the following eighteen normal schools recommend that all nature study work be based upon previous strictly scientific studies: Geneseo, Castleton, Bridgewater, Brockport, McComb, Buffalo, Cedar Falls, Terre Haute, De Kalb, Chicago, Charleston, Peru, Springfield. Mankato, Carbondale, Milwaukee, Che-

ney, and Nashville. It may be readily understood from reading the answers in full that some understand that "nature study" means a systematic and scientific study of nature, while others think it is either a partial or complete study of any objects or phenomena in nature chosen at random. The latter was intended in the question, and was readily so interpreted by nearly every one.

Question 9, Relative to Special Courses in Normal Schools for High School Teachers.

Four answers are so indefinite that I cannot correctly quote them—Jacksonville, Walnut Grove, Cleveland, and Charleston, but a suggestion appears that Charleston favors such courses.

Ten are on record against such a course in the states where the high schools look to the colleges and universities for their teachers—Stevens Point, Milwaukee, Duluth, St. Cloud, Worcester, Bridgewater, Huntington, Westchester, Greensboro and Natchitoches.

Twenty-eight, perhaps in states where high schools accept *prepared* teachers from *any* source, are positive in their opinion that normals should offer courses preparing teachers to teach biology in high schools. Those who seem to be willing to sign a "Declaration of Independence" on this question are the following: Denton, Moorhead, Terre Haute, Greeley, Cedar Falls, Buffalo, McComb, Brockport, Kirksville, Castleton, Nashville, Carbondale, Los Ageles, Las Vegas, Ypsilanti, Springfield, Mayville, Peru, De Kalb, Normal, Emporia, and the following which favor such a course if the normal is preparing teachers for high school teaching (like Lincoln's testimonial for the book—"for anyone wanting a book of this kind, this is the kind of a book he wants"): Baltimore, Winona, Mankato, Cheney, and Trenton, who, while he states that after the regular course is completed he always has special students who work with microscopes and scalpels, yet he expresses the hope that they "will never become teachers of biology with a capital B and emphasis." From the exceedingly modest rank in learning which some of the normals would seem to suggest that they should occupy, little fear need be exercised that too much "biology with a capital B" might be learned or taught.

Question 10, Relative to Advanced Technical Courses in Normal Schools:

Seven answers are either so indefinite or so effectually assume an attitude "upon the fence," that I cannot quote them as either favoring or opposing such courses. Fourteen are positively opposed to such courses, and twenty-one are possibly even more positively in favor of offering such courses, as electives, that teachers may be prepared for teaching effectually in the high schools.

These twenty-one whom I regard as constituting the "honor list" in this respect, are the following: Huntington, Kirksville, McComb, Terre Haute, Denton, Nashville, Mayville, Peru, Las Vegas, Ypsilanti, De Kalb, Normal, Emporia, Carbondale, Castleton, "by adding one more year to the course;" Bridgewater, proposing that one normal in each state shall offer such courses; Moorhead, "if the normal is preparing teachers for high schools;" Chicago, who offers such courses, but does not push them; Mankato, "for normals of college grade;" Los Angeles, "wherever possible;" and Cheney, who is "looking forward to such courses."

The opposing faction, who are apparently willing that the universities and colleges shall be the only conservatories of advanced learning, are the following: Trenton, Greensboro, Worcester, Brockport, Baltimore, Stevens Point, Westchester, St. Cloud, Geneseo, who complains that there is no room; Buffalo, who says, "not in New York;" Springfield, a new normal, who says, like the average sinner, "not now;" Natchitoches, who claims that it would weaken our courses; Milwaukee, who says that such courses are the exclusive function of the university; and Duluth, who says "not until we can teach what we have better. Any college graduate can teach the mere technical. We need naturalists in the normals."

Those who are indefinite, or effectually "straddle" are the following: Jacksonville, Walnut Grove, Cleveland, Greeley, who leaves us to infer what he means when he says "meet the demands;" Cedar Falls, who makes the very pertinent remark, "The other state institutions are very jealous of their lives, and strongly object to more advanced technical work in the normals. Still there is good ground for the theory that normal schools ought to make thorough preparation for teaching in all grades

of public school work;" Winona, who remarks, "Must depend entirely on the work of the school. I am convinced that the normal schools of our country are far from united in spirit or purpose" (how true!); and Charleston, who confesses, "I have no definite opinion on this matter. Such a course might be given, where facilities for special kinds of work are especially good. Mr. Caldwell (formerly teacher of botany here) taught an advanced course in botany in this normal for two years. It was of the same grade as an advanced course in a university. It was a complete success. Students who elected it were well prepared to do the work, and some of the students have become efficient teachers of biology in good high schools."

I think I may be allowed to close the symposium by adding an appendix, which is in no sense offered as the "cope stone of the arch." I will simply give briefly my own answers to the ten questions, based upon my opinions and practices before sending out the quotations.

ANSWER 1. My estimate is that about 8% of those taking my courses afterward teach biology (perhaps without the capital B) in high schools.

ANSWER 2. My courses are entitled biology. I find animals and plants so intimately related in nature that I cannot fully separate the study of them in their natural relations. I therefore blend and alternate the studies, which I find entirely satisfactory in elementary general courses.

ANSWER 3. About 16 2/3% of my course in general biology is given to the study of microscopic animals and plants.

ANSWER 4. I place a reasonable stress on ecology, a part of which is done in connection with structural studies, but mostly in the two field lessons per week during the spring term.

ANSWER 5. I give no particular portion of the courses to physiological studies only, but blend such studies with many structural studies, in cases where functions are apparent or well known. We make no physiological research.

ANSWER 6. We study type forms of each of the great groups of animals and plants, including marine types, varying this method only for demonstration and cursory consideration of any specimens which may be brought incidentally to the laboratory, or secured on field trips.

Answer 7. We proceed from a study of lower to that of higher forms, unless some more important exigency than seasonal convenience should arise.

Answer 8. I think it more important and profitable to the students who afterward teach in the grades lower than the high school to have a course in systematic biology, involving strictly scientific studies, than to have a course in random nature study only (which, however, is also important). A systematic course in scientific study, by scientific methods which will give a student power of independent study, will equip him well for studying any local flora or fauna to which he may go after leaving the local conditions of the normal in which he might have had his local flora and fauna study. What the nature study teacher usually lacks is *greater resources than a knowledge of the objects of local interest.* A knowledge of a few good types of great groups will enable one to interpret a new individual discovered in a new flora or fauna.

Answer 9. I believe that special courses covering a large scope of the science should be offered, as electives, for those who may desire to become fitted for teaching biology in a high school. Normal schools are under as much obligation to the state to prepare teachers for higher grade teaching as for lower grade teaching. What high schools should want is PREPARED teachers from any good institution capable of preparing them.

Answer 10. Normal schools should be sufficiently well equipped with both teachers and appliances to offer at least some more advanced and technical courses, such as embryology, histology and microscopic technique, lectures on evolution, etc. *No kind of an institution should have a monopoly of any phase of learning.* A teacher should be permitted to teach anything he is capable of teaching, and which his pupils are capable of being taught. There will still be plenty of advanced learning that other teachers in other institutions may more effectually offer than any individual teacher can possibly give.

South African coal is finding ready market not only for local consumption but for export. The collieries of Natal produced during the first eight months of this year 929,115 tons.

The United States is now occupying a distinctive position in the pottery industry. From the standpoint of quality and artistic merit, American pottery compares favorably with imported ware.

PHILOSOPHICAL GEOGRAPHY.*

By Charles R. Dryer,
State Normal School, Terre Haute, Ind.

The earliest known philosophical geographer, Strabo, who lived from about 62 B. C. to about 22 A. D., regarded geography as an important branch of philosophy, or the general theory of things. In the first paragraph of his great work on geography he writes:

"If the scientific investigation of any subject be the proper avocation of a philosopher, geography is certainly entitled to a high place. Nor is the great learning through which alone this subject can be approached possessed by any but a person acquainted with both human and divine things, and these attainments constitute what is called philosophy. In addition to its vast importance in regard to social life and the art of government, geography unfolds to us the celestial phenomena, acquaints us with the inhabitants of land and sea, and the vegetation, fruits and peculiarities of the various quarters of the earth, a knowledge of which marks him who cultivates it as a man earnest in the great problem of life and happiness."[1]

It was left to the philosophical genius of Immanuel Kant to discern the fundamental principle at the base of all geography. In the introduction to his Physical Geography, published at Königsberg in 1802, he discusses the general classification of knowlege. Kant is not easy reading, but the following pieced sentences are an attempt to abstract a fair statement of his doctrine:

"The world as the object of our senses is nature, as the object of our inner mind is soul or humanity. Experience of nature and of man make up together world knowledge. Knowledge of man is anthropology. Knowledge of nature we call physical geography. We can arrange our experience knowledge either according to our reason or according to time and space. The classification of knowlege according to reason is logic, according to time and space a geographical description of nature. We can apply the term description to both history and geography, but with this difference, that the former is a description of time, the latter a description of space. History is a narration of occur-

*Read at the Chicago Meeting of the Association of American Geographers.
[1] Strabo. Geography, Book I, Section 1.

rences which have followed one another in time: *geography is a narration of occurrences which are coexistent in space.*"[2]

Alexander Bain, formerly professor of logic in the University of Aberdeen, says in his book on Education as a Science:

"The aims of geography are very well defined. *The conception of occupied space is its foundation;* it is the all-embracing frame work of the outer world in its orderly management. On the great scale, it gives a place to everything and peoples every place."[3]

According to these principles, facts and concepts peculiar to occupied space belong exclusively to geography, and are the only ones that do so belong. Such are location, direction, distance, height, area, form in three dimensions, contents, distribution. As soon as such facts begin to be studied scientifically the distributions cease to be merely static, such as can be shown on a map, and the problem of location, form and content, as influenced or determined by the mutual relations of the phenomena, presents itself. Hence arise several concordant definitions of geography from various sources.

"General geography deals with the general laws of the distribution of every class of phenomena on the earth's surface."—*Prof. Neumann of Freiburg.*

"Geography is essentially the science of topographical distribution on the surface of the earth; the distribution of the great features of the globe, and all that its face sustains, including man himself."[4]—*J. Scott Keltie.*

"Geography is the exact and organized knowledge of the distribution of phenomena on the surface of the Earth, culminating in the explanation of the interaction of Man with his terrestrial environment."[5]—*H. R. Mill.*

"The geography of to-day starts from the point of view of diversity in space, and aims at a scientific explanation of the nature of regions inclusive of their inhabitants. Its task is to investigate the distribution of phenomena in mutual dependence."[6] —*Prof. Alfred Hettner, of Heidelberg.*

It is difficult to see why these statements are not broad enough and definite enough to satisfy any practical geographer.

If in the study of "the distribution of phenomena in mutual

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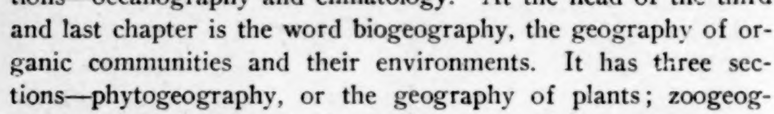
[2] Kant. Physische Geographie, Königsberg, 1802, pp. 1-20.
[3] Bain. Education as a Science, 272.
[4] Keltie. Contemporary Review, 54, 418.
[5] Mill. International Geography, 2.
[6] Hettner. Geographische Zei'schrift, June, 1895.

dependence," we take the evolutionary point of view, geography immediately becomes a problem of environments, of influence and response, of control and adaptation. This idea has been well expressed by Redway. "It would not be a very great breach of the truth," he says, "to say that a camel is a camel because of the desert; a fish, a fish because of the water; a bird, a bird because of the air."[7] The recent papers of Professor Davis are full of this doctrine. "It is the element of relationship," he says, "between the physical environment and the environed organism that constitutes the essential principle of geography to-day."[8] This relation is not confined to living organisms. The control of the environment and the adaptation of the organism are as clearly shown in a volcano or a thunderstorm as in a camel or a cactus.

Mackinder has sketched what he calls the geographic argument as follows:

"The first chapter deals with geo-morphology—the half-artistic, half-genetic consideration of the form of the lithosphere. The second chapter might be entitled geophysiology; it postulates a knowledge of geomorphology, and may be divided into two sections—oceanography and climatology. At the head of the third and last chapter is the word biogeography, the geography of organic communities and their environments. It has three sections—phytogeography, or the geography of plants; zoogeography, or the geography of animals; and anthropogeography, or the geography of man. This chapter postulates all that has preceded, and within the chapter itself each later section presupposes whatever has gone before. To each later section and chapter there is an appendix, dealing with the reaction of the newly introduced element on the elements which have been considered earlier."[9]

For convenience this may be diagrammed as a linear enchainment of geosphere (earth as a whole), lithosphere, hydrosphere, atmosphere, biosphere and psychosphere, although Mackinder clearly indicates that each link has direct connection with every other link; that the scheme is not so much an enchainment, as an entanglement not easily shown in a diagram.



[7] Redway. Proceedings National Educational Association, 1900, 413.
[8] Davis. Proceedings American Philosophical Society, 41, 240.
[9] Mackinder. Geographical Journal, 6, 376.

Mackinder's Enchainment

Now come the dualists who, apparently appalled by the complexity of relations, seek to cut the knot by dividing the links into two groups, and saying that geography involves only the relations of one group to the other. This reduces geographical relations mathematically from fifteen classes to five or even one. Dualism takes many forms, of which the time-honored fetish of the schools, attributed with doubtful justice to Ritter, is dominant. It has been expressed in a thoroughgoing way by Professor C. A. McMurry. "Geography," he says, "is the study of the earth as the home of the man. The study of the earth alone, its phenomena and forces, its vegetation and animals, its rocks and atmosphere, is natural science pure and simple. The study of man in his work and progress, in his struggles and representative deeds, is history. The study of the earth as related to man is geography."[10] Geography as taught by McMurry is not even a study of the earth as the home of man, but rather a study of man using the earth.

Professor Davis proposes to bisect the chain between the organic and the inorganic links, placing plants and animals on the same side of the fence as man.

H. R. Mill, in one of his latest papers, selects the lithosphere, or that part of the earth which is relatively most permanent, with which the other more mobile and changeable spheres must establish geographical relations. He defends with much plausibility the principle that "geography is the science which deals with the forms of relief of the Earth's crust, and with the influence which these forms exercise on the distribution of all other phenomena."[11]

In fact, a strong case may be out for the atmosphere as the central factor in geography, and perhaps also for the hydrosphere. Such schemes furnish an excellent exercise for students, and a workable organization of geography may be made around any sphere or any group of spheres as a nucleus. Of all forms of dualism that of Professor Davis seems to have the best claim for scientific and pedagogic recognition; but the serious objection to all of them is that they are essentially illogical and unphilosophical. They do not grow naturally out of a consideration of all the material, but are arbitrary and artificial expedients.

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[10] McMurry. Educational Review, 9, 443.
[11] Mill. Geographical Journal, 25. 1.

like the botanical system of Linnæus. Each is a partial and one-sided view of the manifold and complex geographical relations which exist between all the spheres, mutually and concurrently. *Complete philosophical geography cannot be anything less than a synthesis of all the spheres in all their relations.*

In support of this view good authorities may be quoted almost *ad libitum,* and in spite of misunderstanding and misrepresentation, at the head of them stands the greatest of pre-evolutionary geographers, Carl Ritter. In the introduction to his little book on Comparative Geography, well known in this country through the translation by Gage, he writes:

"When Geography ceases to be a lifeless aggregate of unorganized facts, and becomes the science which deals with the earth as a true organization, a world capable of constant development, carrying in its own bosom the seeds of the future, to germinate and unfold, age after age, it first attains the unity and wholeness of a science, and shows that it grows from a living root; it becomes capable of systematic exposition, and takes its true place in the circle of sister sciences. . . . Geography is the department of science that deals with the globe in all its features, phenomena and relations as an independent unit. . . . There is above all thought of parts, of features, of phenomena, the conception of the Earth as a whole, existing in itself and for itself, an organic thing, advancing by growth, and becoming more and more perfect and beautiful. Without trying to impose on you anything vague and transcendental, I wish you to view the globe as almost a living thing—not a crystal assuming new grace by virtue of an external law—but a world, taking on grandeur and worth, by virtue of an inward necessity. The individuality of the earth must be the watchword of re-created Geography."[2] Undoubtedly this is transcendental geography, an approach to the Stoic conception of an *anima mundi,* or world-soul, of which geography should be the psychology.

Ritter's conception, shorn of its transcendentalism, mysticism, and teleology, and reduced to plain terms of common sense and modern science, has been admirably set forth by J. F. Unstead, a young graduate and instructor of London University, in an article in the Geographical Teacher. After reviewing the current schemes of the distributionists and the dualists and giving to

[2] Ritter. Comparative Geography. XVII-XXI.

each due credit for certain advantages, he notes that any division of the phenomena into two groups necessarily emphasizes the relations between the groups and excludes or neglects relations within the group, and concludes that any line of cleavage is objectionable.

"Geography," he says, "does not concern itself with any one feature of the Earth's surface or of its inhabitants, but with the mutual relations of all the phenomena that exist together and together form a kind of complex—a macro-organism, as it has been called—which is the object of geographical study. . . . The complex is spread out, as it were, over the Earth, and the various parts are related to one another according to their positions upon it. Hence the space relations of the phenomena are matters which must be known and taken account of by the geographer. The ideas expressed in this paper may be summarized by a very tentative suggestion of a definition of geography; *Geography is the science which investigates the conditions of the macro-organism and the space-relations of its component parts.*" [13]

This thesis finds support in two eminent French geographers. The late Professor Lespagnol of Lyons, in the preface to his *Geographie Generale,* writes:

"The earth is a sort of organism of which all the parts are in reciprocal dependence. It is the original role of geography to put in contact the facts which other sciences study in isolation, and to replace in the complexity of natural conditions, in the movement of life, the phenomena of the physical and organic world. *The geographic synthesis,* by its study of relations, becomes a profound expression of reality, discovers new horizons, and gives to facts all their significance and importance. The magnificent accord of the Earth and all which germinates and develops on its surface, the harmonious determinism of natural life, give to geography all its beauty and fix its ideal. It endeavors to establish the reciprocal relations of facts of every order, the enchainment of which constitutes the life of the earth." [14]

Professor Gallois, of the University of Paris, writes: "In the measure that the sciences have developed, especially the natural sciences, which have for their object the study of diverse orders

[13] Unstead. Geographical Teacher, 4, 19.
[14] Lespagnol. Geographie Generale, V, VI.

of phenomena, in proportion as our horizon has extended by the progress of discovery, permitting fruitful comparisons, the relations of all these facts with one another have been better and better perceived, and this reasoned whole has ended in constituting a true science, which is geography, as it is uniformly conceived to-day, whenever there are geographers."[15]

And, finally, that brilliant French-Scotchman, Professor Patrick Geddes of Edinburgh, architect, landscape gardener, civic reformer, biologist, sociologist, geographer, and all around genius, has said in a lecture: "All sciences are logical artifices by which we focalize our attention upon one thing or aspect, with consequent distortion or disproportion, as through a microscope or telescope. They are geolyses or cosmolyses. Geography is more than a science—it is a synthesis—the concrete synthesis of the *Weltall* in evolution."

It may be that we shall find it expedient to select from this vast synthesis of phenomena a few important relations which we shall call school geography, and that the real esoteric philosophy of geography will be taught only in the universities. It may be that in geography, as in theology, some simple Apostle's Creed will be found for the laity more edifying; but for the high priests and devotees, will anything short of the *Catholic* doctrine of Ritter, Lespagnol and Geddes, prove sufficient for salvation and give peace unto our souls?

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[15] Gallois. Annales de Geographie, 14. 211.

A NEW SCHOOL CHRONOGRAPH, AND THE DETERMINATION OF "G."

By Harrison H. Brown,

Pratt Institute, Brooklyn.

The writer has long felt that the laws of falling bodies should be studied as *a simple case of uniformly accelerated motion* in a first course in physics, and that the best method is to measure the time of free fall for various distances, calculate the average velocity as $s \div t$, to assume that the acceleration is uniform, and *hence that the final velocity is twice the average,* and obtain the acceleration by dividing the final velocity by the time. The correctness of the assumption is verified by the agreement of the values derived for the acceleration from the different times and distances.

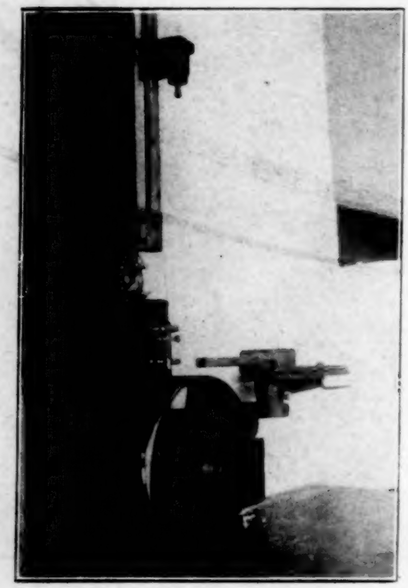
Inclined planes or wires do not give us the value of "g" directly, nor does the Atwood machine. All these methods add appreciably to the student's difficulties, even if regarded as approximate, while the elimination of the moment of inertia errors is quite beyond his capacity till long after the time when an experiment on simple accelerated motion might have been of use to him.

What was needed was an inexpensive chronograph reading to thousandths of a second, yet simple and strong. The distance to be measured is limited by laboratory conditions to a very few feet.

The present apparatus has been used for falls of 36, 64, 100, and 144 cms, the calculated times being 0.271, 0.361, 0.452, and 0.542 seconds respectively. The laws of falling bodies fall right out of these numbers, and the set is enough for a convincing exercise.

The distances are not measured directly by a meter stick, but by a set of wooden rods with metal ends (wood screws with flat heads) of these exact lengths. In this way the distance may be known to a tenth of a millimeter. Of course, other intermediate distances may be used at will; indeed, probably one such might well be specified for each student to add to the individuality of his work. As the tracings are preserved in the note-book and very easily checked by the instructor, there is no chance of dependence of one student on another.

The chronograph consists of a 10-inch pulley with a 3-inch face, suitably supported, and carrying on one edge a pin, which engages with a well-made circuit-breaker in series with an electromagnet and a couple of storage cells. The magnet has an extension from its core, of soft, round iron, which carries a split sleeve of brass so that a 3/8-inch bicycle ball is held by the magnetic force just free of the iron. A small Kendrick and Davis rheostat is also in the circuit to weaken the field to a minimum.

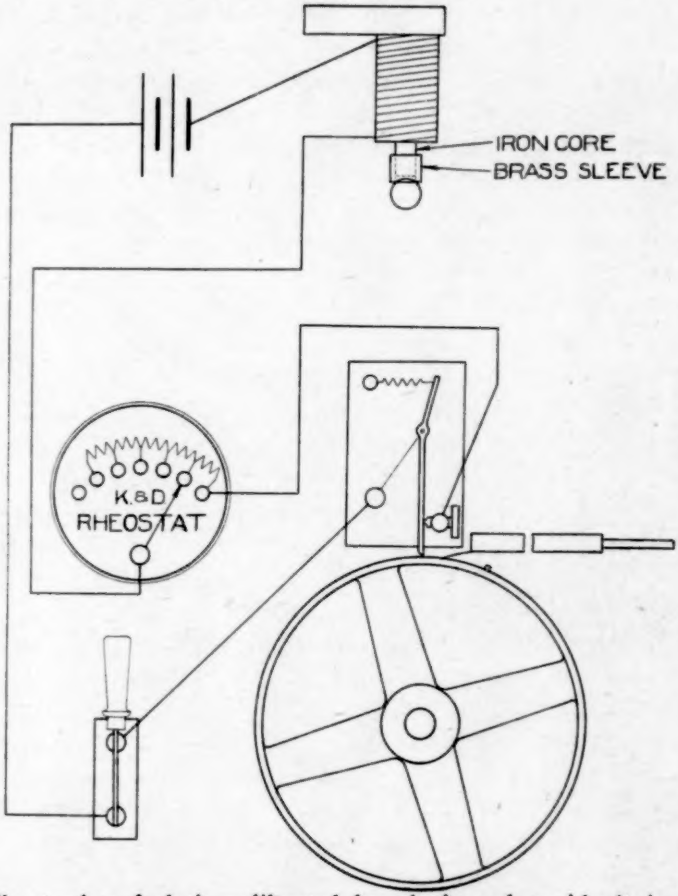


Adding machine paper is cut from the roll to length, placed round the pulley, one end pasted over the other, and lightly smoked. The heat should stretch the paper smooth. A tuning fork vibrating in a period of 1/100 second is held in a cast iron holder and tilted forward at will till the paper stylus on one prong touches the smoked paper. A stop is provided for this motion.

The ball is placed in position, and current reduced to a minimum. The wheel is rotated very slowly by hand till the ball drops, which marks the "zero" position by a dent which can be located very accurately. To avoid errors from jarring of the building, two or more trials are made.

The ball is now replaced, the wheel turned back about a quarter revolution, the fork set in vibration and tilted downward on the paper as the wheel is set in motion by the other hand. Taking care that the stylus is set near the dropping point, and that the velocity of the wheel shall be fairly uniform, the time is read off directly in thousandths of a second. This is rendered easier if, after taking the race, a datum line is run through the sinusoidal curve by rotating the wheel with the fork still. The record is cut across with a penknife, the date, distance, name of ob-

server scratched in, and fixed by running through very thin shellac. The time may be counted at leisure.



The tuning fork is calibrated by placing alongside it in the tilting piece a signal magnet in series with a seconds pendulum break and a cell of battery, and taking a simultaneous trace of fork and standard time. The interval compared should be 2 or 4 seconds to eliminate possible error due to eccentricity of position of time breaker.

The tuning fork costs one dollar, its starter thirty-five cents, the signal magnet one dollar and thirty cents. All are sent on receipt of price by the Harvard Apparatus Co. of Medfield, Massachusetts. The pulley, turned and bored, cost one dollar and thirty cents. The total cost of the materials for the entire apparatus was about six dollars.

The following readings were taken to determine rate of fork, in each case for a period of 2 seconds: 200.1, five times; 200.2, five times; ten readings in all. The fork may be too rapid by about one part in 1,500.

For a free fall of less than 200 cms. the fork may be regarded as correct.

The following table is from data taken consecutively by Mr. Black:

No. of Observation	Distance cms.	Time—Seconds Observed	Calculated	Error	"g" by Obs.	Time Corrected	"g" Cor. Obs.
1	36.00	0.277	0.271	+.006	939	0.276	944
13		0.275		.004	952	0.274	959
14		0.273		.002	966	0.272	973
15		0.272		.001	973	0.271	980
16		0.272		.001	973	0.271	980
17		0.272		.001	973	0.271	980
18		0.272		.001	973	0.271	980
19		0.273		.002	966	0.272	973
20		0.272		.001	973	0.271	980
2	64.00	0.354	0.361	—.007	1020	0.353	1024
8		0.363		+.002	968	0.362	976
9		0.363		.002	968	0.362	976
10		0.362		.001	976	0.361	980
11		0.362		.001	976	0.361	980
12		0.363		.002	968	0.362	976
21	100.00	0.452	0.452	.000	978	0.451	984
22		0.440		—.012	1034	0.439	1038
23		0.451		—.001	984	0.450	988
24		0.453		+.001	974	0.452	978
25		0.452		.000	978	0.451	984
26		0.450		—.002	988	0.449	992
3	144.00	0.543	0.542	+.001	976	0.542	979
4		0.542		.000	979	0.541	984
5		0.543+		.001	976	0.542	979
6		0.542		.000	979	0.541	984
7		0.543		.001	976	0.542	979

From an inspection of the fourth column it appears that there is a lag in the release of the ball of about 0.001 second, and the last two columns are calculated making this correction in the observed time.

Taking all readings, we have from the 26 cases "g"=982 with a probable error of 6.

There is a source of error which is difficult to prevent, that due to jarring of the building. This probably accounts for the relatively great errors in cases 1, 2, 13, and 22. In case 22, the

wheel was run at a very slow speed. A second source of error is in having different wheel speeds at the beginning and end of the trace, if the stylus of the tuning fork is far from the point where the ball strikes the wheel. To be strictly accurate, instead of reading time from indentation to indentation made by the ball, one should strike backward from these points with a pair of compasses spread to the distance between stylus and dropping point, and measure the time between the two arcs.

Omitting readings 1, 2, 13, and 22, which are manifestly in error, we have from the remaining 22 cases "g"=980.3 with a probable error of 2.

Omitting the "lag" correction of .001 sec. and omitting cases 1, 2, 13, and 22—g is 974 with a probable error of 3.

Hanging a weight to a cord which runs over the pulley and is attached to the releasing pin, we may use the apparatus to study the laws of uniformly accelerated rotary motion. Suitable allowance should be made for friction.

Using the signal magnet and fork, we have a chronograph accurate to a thousandth of a second, with a possible range of 5 to 10 seconds, to measure time between any two events which can be related to breaks in an electric circuit. A trace can run right over its first revolution without confusion.

Anyone having one of Gaertner's force tables can make a piece for three or four dollars like an earlier form of this apparatus, with which even better results than the above were obtained. Information will be given by correspondence to those interested.

The model shown was built in coöperation with Mr. N. H. Black of the Roxbury Latin School, who aided very materially in overcoming the difficulties in making a reliable circuit breaker. The apparatus may be seen in his laboratory.

ON THE DEFINITION AND SCOPE OF PLANE TRIGONOMETRY.

By Robert E. Moritz.

University of Washington, Seattle.

It is a noteworthy fact that amidst an abundance of literature bearing on the teaching of elementary mathematics, scarcely a reference can be found anywhere touching the study of trigonometry. Certainly of all subjects that make up the high school curriculum none has received so little attention at the hands of critics as has trigonometry. The writer would not know where to look for a single article published in this country within the past twenty-five years, which deals exclusively with the pedagogy of trigonometry. The subject seems likewise to have escaped the attention of committees dealing with secondary mathematics. The well-known report of the Committee of Ten on secondary school studies, with its painstaking discussions both as to subject matter and methods of teaching of every other branch, entirely ignores the subject of trigonometry. The Committee on College Entrance Requirements, in their report before the N. E. A., 1899, dismiss the subject of trigonometry with the remark that when offered as a high school subject "the matter should be restricted to that needed for the solution of plane triangles." Nor does the writer recall that School Science and Mathematics, with secondary science and mathematics for its distinctive field, has ever offered its readers a title dealing with trigonometry.

Whatever may be the cause of this lack of recorded discussion, it certainly cannot be attributed to a lack of importance of the subject. Few subjects combine in so high a degree, as does plane trigonometry, both practical and disciplinary elements. If algebra and geometry are the pillars on which all exact science rests, trigonometry is the lintel which bridges these pillars and supports the superstructure. At this point algebra and geometry are merged into one in the investigation of the circular functions. This, together with the constant reference to arithmetic in its abundance of numerical processes, makes trigonometry the ideal mathematical discipline for the senior year in high school, a most fitting capstone for the mathematical curriculum in the secondary schools. It answers all the purposes of reviews, in that it makes a constant demand upon the pupil's store of arithmetic, algebraic,

and geometric knowledge, yet stimulates further exertion in the application of this knowledge to new developments. Besides, plane trigonometry abounds in new conceptions and ideas. What better introduction to the idea of coördinates, both Cartesian and Polar, is there than through the definitions of the functions as ratios of coördinates? What more natural introduction to curve tracing than that offered in the construction of the graphs of the trigonometric functions? What better illustration of the gigantic power wrapped up in the science of mathematics, than that furnished in the use of logarithms? What better viewpoint for a glimpse of the mystic beauties of mathematics, than at the theorems bearing the names of Euler and Demoivre? To this must be added that trigonometry lies at the foundation of all subsequent mathematical study, that a knowledge of its elements is indispensable to almost every quantitative science, as physics, and all its subdivisions, chemistry, geology, astronomy, meteorology, geography, surveying, and navigation, and that it is helpful even in such studies as economics and psychology, and useful to a dozen arts and crafts. Nor can the absence of a literature on the teaching of trigonometry be attributed to so high a degree of perfection in the organization of the science as to render further discussion needless or unprofitable. Trigonometry to-day is probably the least organized of the mathematical disciplines from arithmetic to and through the infinitesimal calculus. There appears to be no recognized order of precedence in the treatment of different topics by various authors.

This lack of recognized order is due, no doubt, to an absence of unity in the conception of the subject. While most authors attempt to cover a certain number of traditional topics under the head of trigonometry, they are widely at variance as to what constitutes trigonometry proper. Scarcely two authors agree in their definition of the science. Out of some twenty texts which are accessible, the writer gleans the following definitions. With one or two exceptions, the definitions are from texts published within a decade:

1. Trigonometry is that branch of pure mathematics that treats of the solution of triangles.

2. By trigonometry is understood the calculation of triangles from three suitable parts.

3. Trigonometry is that branch of mathematics which treats of methods of subjecting angles and triangles to numerical computations.

4. Trigonometry primarily treats of calculations concerning lines and angles.

5. Trigonometry is that branch of geometry in which relations of lines and angles are treated by algebraic methods.

6. Trigonometry treats of the properties and measurement of angles and triangles.

7. Plane trigonometry comprises all algebraic investigations with respect to plane angles, whether forming a triangle or not.

8. Analytical trigonometry treats of the relation of lines and angles by algebraic methods. In plane and spherical trigonometry these relations are applied to the solution of plane and spherical triangles.

9. Trigonometry is that branch of algebra in which undulating functions are considered.

10. Trigonometry is the mathematical doctrine of angles, sides and areas of triangles, plane and spherical, together with that of other quantities intimately related to these. Trigonometry embraces also goniometry or the elementary theory of singly periodic functions.

This list by no means exhausts the variety of definitions that are current, but it must suffice to show the utter lack of unity in the conception of what trigonometry really is. It will be observed that no two of these definitions are equivalent. Thus the first definition makes the solution of triangles the province of trigonometry, without specifying the method of solution to be employed. The second definition restricts the method to calculation, the third implies that it is not the calculation itself but the methods of calculation that trigonometry deals with. The fourth by making the solution of triangles the primary object of the science, suggests a broader content than mere solution of triangles, and so on down the list. According to (5) trigonometry is a branch of geometry, according to (9) it is a branch of algebra. By (8) trigonometry is a branch of a more general science analytical trigonometry or goniometry, while by (10) goniometry is made a part of trigonometry.

The inadequacy of the first group of definitions, which make the solution of triangles the object of trigonometry, must be ap-

parent on a moment's reflection. This conception is not even broad enough to cover a number of elementary topics which have become a conventionalized part of the science. What bearing has the study of radian measure, or of inverse functions, or of the general values of angles corresponding to a given function, or a study of the graphs, on the solution of triangles? Logically these topics should be omitted by authors who see in trigonometry nothing more than a method of solving triangles. But since custom demands their treatment, they are introduced indifferently at whatever point the whim or fancy of the author may dictate. There are other topics as the solution of trigonometric equations, most of the matter under trigonometric identities, the chapters on Demoivre's and Euler's formulæ, and on hyperbolic functions, which must appear as unrelated appendages, from the standpoint of those who limit the domain of trigonometry to the solution of triangles.

It may not be amiss to consider for a moment the recommendation by the Committee on College Entrance Requirements that the teaching of trigonometry in the secondary schools be restricted to what is *actually needed* (the italics are mine) for the solution of plane triangles. As well confine the teaching of percentage to what is actually needed to use an interest table. For in what consists the so-called knowledge of solving triangles? Is it not merely in knowing how to use a key which contains every possible solution? Every conceivable triangle was solved long ago by the men who constructed the trigonometric tables; these tables contain the answer to every problem that can be set. The formulæ give the rules by which to proceed, the tables give the unknown parts when a sufficient number of other parts are known. The student is deluded in believing that he has solved the triangle when he has done as little of the real work as the accountant who figures compound interest from a table. That this knowledge of solving triangles is of considerable practical importance in certain arts and sciences, is no sufficient reason for devoting a semester's work to its acquisition. All that is really necessary for the solution of triangles could easily be taught in connection wth plane geometry and algebra.

Some writers recognize the difficulty into which this narrow conception of the subject leads them, and seek to escape it by attaching to the definition some saving clause, as that "trigonom-

etry is the science which has the solution of triangles for its primary object," or that it deals "primarily with the solution of triangles and secondarily with the general relations of angles and their functions." If the secondary aim is not stated, such definitions, of course, leave the way open for anything and everything that the author may desire to introduce. In any event such definitions abandon the possibility of a unitary conception of the subject from the outset.

The root of the difficulty lies in the adherence by the majority of our authors to a conception which the science has long since outgrown. It is time once for all to divorce the meaning of the term trigonometry from its etymology, or else replace the term by some more fitting one. Etymologically geometry means land measurement, but who would think of making methods of land division and measurement the aim or even the principal aim of the science? So trigonometry, which originated, it is true, in the attempt to solve triangles by numerical methods, has become vastly more than this. Its central idea is no longer triangles, but angles and their functions. It only remains to shift the emphasis where it belongs, from the solution of triangles to the relations between angles and their functions. With trigonometry as the science of angular magnitudes, everything ordinarily treated under that head can be organized into a coherent whole.

The writer is well aware that the lack of unity in the treatment of trigonometry is often attributed to inherent causes. Thus Young (Teaching of Mathematics, p. 287) regards the subject devoid of peculiar characteristics or of "a clear cut central idea which would serve to give the subject its own individuality." He goes on to say, "Arithmetic has to do with the number concept. algebra with the generalized number concept and the equation, and geometry with the space concept and its problems. These central thoughts are distinct and fundamental, and though the masses of material that their treatment has developed have many inter-relations and common borderlines, still each of these subjects has its own very marked individuality."

This and similar remarks lose their force the moment we conceive of the angle as the central idea of trigonometry. With this conception its field becomes as clearly defined, its character as individual and distinct, as that of arithmetic, algebra or geometry. That algebraic methods are employed in treating what is

really a geometric concept, no more destroys the individuality of this science than it does any other branch of mathematics based upon a knowledge of algebra and geomerty. The angle as the central idea, not only introduces unity into the science, but it emphasizes that element of the subject which is of greatest importance. A knowledge of the relations between angles and their functions, that is fundamental. Without this knowledge progress in higher mathematics and in a dozen applied sciences is impossible, for most branches of science, a knowledge of the solution of oblique triangles is of minor importance. The solution of triangles, far from being the aim of the science, is only one of its many applications, though an important one.

Again the objection may be raised that the definition which makes trigonometry the science of angular magnitudes is too broad, that taken in its broadest sense this definition covers the theory of elliptic functions, and of Fourier's series, and other branches of mathematics which cannot be even touched upon in an elementary course of trigonometry. The same objection could be raised against the usual definition of arithmetic which, taken in a broad sense, includes the whole of the theory of numbers, and against geometry which has a dozen or more branches which are not even mentioned in a course of elementary geometry. Rather than an objection, it is a decided advantage to have the confines of any subject widened, so that the beginner may be pointed to applications and developments far beyond the outlines of his present study. The usual treatment which makes the solution of triangles the end of the science, deprives the student of the most important stimulus which comes from the consciousness that there are regions beyond, whose exploration requires the mastery of the principles at hand.

With angular magnitudes for its domain, trigonometry could be enriched by the introduction of several topics, which properly belong here, and which could be easily covered in the time usually allotted to the subject, now that spherical trigonometry is seldom attempted in the same semester with plane trigonometry. Among others may be suggested the following:

1. The study of the graphs

$$y = e^x,\ y = ae^x,\ y = ae^{bx},$$

in connection with logarithms.

2 The graph $y = a \sin (bx+c)$.

3. The graph $y = ae^{-bx} \sin cx$.

4. The study of expressions in which the angle is a function of the time, as

$$y = a \cos \varphi t, \quad y = a \cos \frac{2\pi t}{T}, \quad y = a \sin (\varphi t + \epsilon)$$

5. Composition of harmonics, as

$$y = a \sin (pt+\epsilon) + b \cos (pt + \epsilon) = \sqrt{a^2+b^2} \sin (pt + \epsilon_1)$$

6. Graphs representing compound periodic motion, as

$$y = a^1 \sin b_1x + a_2 \sin b_2x + a_3 \sin b_3x.$$

It would carry us too far to attempt a discussion of the advantages of a knowledge of the topics here suggested. The exponential curve, the deformation of a wave curve corresponding to a change in its amplitude or wave length, the curve of damped vibrations, the conception of angular velocity and periodic time, that of simple and compound harmonic motion and of the composition of harmonics, each of these conceptions are of fundamental importance to a number of sciences. There is no reason why the student should not be introduced to these conceptions, which find their clearest expression in their mathematical form, at the time when he is studying angular magnitudes.

With a thorough organization of the matter ordinarily presented under the head of trigonometry, and its possible enrichment as outlined above, the science deserves to occupy the foremost place in any high school or college curriculum not only because of its disciplinary and practical value, but for its cultural value as well. In the mastery of logarithms, which strips the most complicated and laborious calculations of their difficulties and irksomeness, the student cannot help but become conscious of the tremendous power of mathematical methods. In the application of algebraic processes and symbols to geometric magnitudes he is initiated into a most far reaching method of modern research, that of analytical geometry. The study of trigonometric graphs should give him a working knowledge of an important aid in every field of scientific activity. The study of the trigonometric and logarithmic series, and their use in the computation of logarithmic and natural functions, open up a new field of thought and its application to practical ends. The actual use of the tables familiarizes the student with the principle of interpolation, a knowledge of which is demanded wherever tables are used.

Besides these conceptions and processes, the importance of which must appeal to all, there are an abundance of others, which open the door to higher realms of thought. The simplest application to imaginary and complex numbers, reveals a new conception of addition and multiplication; in the solution of the roots of unity an otherwise unsolvable problem is solved in all its generality; imaginary angles lead to the unsuspected region of hyperbolic functions and even the great subject of Groups may be foreshadowed in various ways. Truly, when viewed as the science of angular magnitudes, no other subject is more stimulating, more practical, or richer in vitalizing conceptions than trigonometry.

HOW GEOMETRY SHOULD BE LEARNED.

By H. J. Chase,

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It is likely that the proverb "everything has been said" applies to geometry, as much as to any other subject. Therefore what I have to offer, though wholly the result of my own experience and observation as a student and teacher of geometry, may include nothing that is new—nothing that, true or untrue, has not been submitted heretofore to the consideration of educators.

I know very well that I am not the first to contend that geometry should be learned by the inductive, instead of the deductive, method; but so far as I am aware, I am the only one who maintains that geometry should be one of the common branches—as common as arithmetic, geography, or history. I assert that children who can halve odd and mixed numbers and read directions for the use of a ruler and compasses, are sufficiently advanced to begin the study of geometry and to pursue it with great mental profit. I assert that they can discover for themselves nearly or quite all the facts that constitute elementary geometry—the facts usually stated as theorems, corollaries, etc.—and that, in making these discoveries, they will gain a much better discipline than is gained by studying the subject in the usual way.

If the experimental be the proper method of learning the natural sciences, it is pre-eminently the proper method of learning geometry. It is more easily and completely applicable to geometry than to any other branch. The apparatus is so simple—only

a ruler, a pair of compasses, a pair of scissors, and, a little later on, to save time, a protractor and parallel rulers. The material is unruled paper—wrapping paper will answer very well—wooden prisms, pyramids, cylinders and cones; pasteboard for constructing these figures, and sawdust, sand or grain for testing their capacities. Add to these a hollow hemisphere, which any tinsmith can make, and you have the outfit for learning elementary geometry—plane and solid—in one year's time by children of no more than eleven or twelve years of age.

Of course more time can be taken, if it is thought best; but there is little danger that even very young children will be overtaxed; for, although they will learn a great deal, it will be in a way that will subject their minds to no undue strain. On the contrary, their mental powers will undergo a development due to actual experience, and therefore genuine. In addition to the knowledge of geometry that they will gain. the children will receive a training of the hand and the eye that will be of no small value, and many very practical lessons in composition. Constant use of so simple an instrument as a pair of compasses develops a degree of dexterity by no means to be despised; and the necessity of devising some form of statement for the discoveries that are constantly being made tends to develop ability of expression, especially with respect to clearness and precision. Since the directions have to be followed with care, one of the first things that the children learn will be to read understandingly.

My first experience with inductive geometry was in a country high school, in which the majority of the pupils were poorly fitted to take up high school work. Seeing that the class in geometry was making very little progress, although the text-book was an unusually simple one, I devised a series of directions, by following which they could discover the facts whose formal statement and demonstration seemed to be making so little impression upon their minds. I found that by actually constructing the figures in the prescribed manner, instead of supposing them to be so constructed, by making lines and angles whose relations actually conformed to the given conditions, the pupils acquired a much clearer idea of the propositions; and in most cases they were able, at the conclusion of an exercise, to make their own statements of the facts to which it had led. In a few months the class had gone through the book and had time to review it by the usual

method. Most of them could have passed the ordinary college entrance examination in geometry, and all of them knew something of the subject.

I had prepared, meantime, a manuscript embodying the method, and for several years thereafter, that is, in the later 80's, I tried, without success, to get a publisher, tried to bring the method to the notice of the educational world, but almost equally in vain. I remained firm, however, in the conviction that I had hit upon the right method for beginners. I examined many "Introductions" and "Books for Beginners" and satisfied myself that I had not been anticipated. I used the method with several succeeding classes, and finally, a few years ago, in an ungraded school in one of the gulf states.

Not a pupil in this school could have passed the examination to enter the ordinary high school. All who could read and "cipher" a little were formed into a geometry class. In four months' time this class had covered all of plane geometry and had begun solid geometry. Some of the pupils, whom I had considered too young to take up the subject, and who had been admitted to the class only because of their importunity to be allowed to try the exercises, surprised me by doing as well as many of the older ones. Fully half the class had not finished fractions at the time of beginning geometry, and some of them were by no means fluent readers. All of them became interested at the start, and their interest did not flag. The recitation was the last of the day, and if, at the closing hour, they had not finished the investigation in which they were engaged, they frequently continued it of their own accord. More than once I was obliged to insist that further consideration of the subject in hand be postponed to another day.

The fact that children like this method and that they gain their knowledge in what must be very much the manner in which the original investigators gained it, ought to be taken, it seems to me, as very strong evidence that the method is pedagogically sound. At any rate, my experience has been that the pupils who have to learn geometry by the deductive method save time by going over the ground first by the experimental method—not a little of the ground, but the whole of it. The majority of high school pupils are not sufficiently mature to appreciate the force of deductive reasoning, especially with reference to matters that are outside their experience.

Those who have discovered facts and verified them by scores, hundreds and, in some cases, thousands of tests, are likely to have as vivid a realization of their truth, and the necessity of their truth, as are those who have had those same facts merely poured into them, and demonstrations poured in on top of the facts. So far as children are concerned, even if the same be not true with regard to adults, far more of genuine mental discipline comes from doing things than from supposing them to be done. Supposing may be well enough for those who have had a little experience; otherwise its value is decidedly dubious.

As a record of what the Greeks had achieved in mathematics, Euclid's Elements has its value; but, in reality, the work is a series of exercises in logic rather than a mathematical treatise. It contains no facts of any importance that would have remained hidden from the world if the book had not survived its author. In other words, for grown up people who want to learn how to split hairs, Euclid's Elements, or the books modeled on it, may be all right; but for boys and girls who wish to learn geometry, they are altogether unsuitable. I may be told that boys and girls do learn geometry out of these books. Well, admit that some of them do; the total results of adherence to a method that, in all probability, never was intended for any but mature minds, that certainly is not adapted to any but mature minds, are simply contemptible, both in quantity and quality. Less than ten per cent of our children enter the high school, that is, less than ten per cent get the opportunity to study geometry. For the reasons that I have been trying to indicate, it is safe to assume that not more than half of this ten per cent learn very much of the subject. By the adoption of the experimental method, the subject could be brought within the reach of a majority of the children in the grammar and even in the ungraded schools, and more of it learned by them in less time than is now learned by the insignificant fraction who are studying it by the deductive method

I am not conscious of any disposition to underrate the value of the deductive method in geometrical investigation. I feel sure, however, that it is not the method for beginners, and, moreover, that for the establishment of facts that are evident to everyone, for the removal of misapprehensions that no one ever entertained, its employment is absurd. If the mental training value of Euclid's Elements were a tithe of what the professed admirers of the work allege, it ought to have led long ago to its being discarded as a text-book for children.

PHYSICS AS A PEDAGOGICAL SUBJECT.

1. Introduction to the Pupil.

By J. Harry Clo,

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Within the last few years an unusual interest has been manifest in the teaching of elementary physics, and much has been said and written upon the various aspects of physics as a branch of elementary study. Much criticism has been directed toward beginning physics, presumably high school physics, being brought about largely by imperfections in the teaching of the subject as indicated by an apparent lack of interest and popularity among high school pupils. The decrease during the last twenty years in the number of pupils who voluntarily choose physics in an elective curriculum, is generally ascribed to the teacher's failure to make the subject interesting and attractive. It is generally conceded that the teacher is greatly handicapped by lack of apparatus, and that the time devoted to physics is not sufficient, but with these exceptions the criticism has been directed toward the teacher and his general methods. The tendencies seem to be to accept the subject matter and methods of treatment of the present physics courses as hopelessly predetermined, and to direct our efforts for improvement toward conditions, curriculi, etc. Along with a rather unusual collection of subdivisions which it contains, we have inherited many uniquely arranged principles and methods of study, among which comparatively few changes have been made. Other sciences have sprung up, have become differentiated and have been systematized; their paths of development pedagogically and scientifically have been marked out and they have followed them. Compared to these sciences physics can hardly be said to have passed through an originating process. It has not been systematized and at present it develops in every direction and in almost every field. The other sciences make use of what is often termed the scientific method in a definite and uniform manner; in physics, the science to which that method owes its greatest development, its application is not always an assured remedy for the elementary student. The other sciences have made use of all possible generalizations, classifications, instructive nomenclatures, etc., as aids to the elementary student. The first of these is perhaps the only one that finds a place in

physics as it is generally taught to-day, and its application is far from complete.

That physics among high school studies and also in college curriculi has not grown in favor seems to be a fact, but it seems at least erroneous to ascribe this condition of affairs to lack of interest in the subject or to the failure of the teacher to make the subject "appeal to" the average pupil. Surely, if physics, with its beautiful spectacular experiments, its striking, almost magic phenomena, is not interesting, what subject can be made interesting? Moreover, if lack of interest and attractiveness has caused its disfavor, why is the complaint almost equally prevalent among good teachers and poor, in splendidly equipped laboratories as well as in meagerly equipped "recitation rooms"? A close study of the difficulties among the students themselves has led to the conclusion that far from being dull and tedious, physics is interesting and attractive, but that it is peculiarly difficult to learn, not so difficult, perhaps, to understand temporarily, but to assimilate thoroughly and to know. The pupil cannot acquire a grasp of the subject. Things are simple after the teacher has explained them, but the understanding of one thing does not insure the mastery of the next. In other words, there is an absence of something—simplicity, unity, relationship, or what not—in the subject as it reaches the pupil. From these considerations it would seem fair to the teacher, that along with the study of purposes, conditions, etc., we should inquire into the subject itself to determine whether or not there are within it either natural or acquired characteristics which render it peculiarly difficult as compared with the other sciences among which it has come to be classed.

The subject matter of physics is not as new to the pupil as is that of many of the other sciences, but the methods of study are not only new but very unusual. In preceding studies he begins by acquiring a nucleus of knowledge upon which to build, and by gradually mapping out his own individual method of procedure—perhaps wholly unrecognized, but nevertheless definite and efficient—he learns to study the new material that is given him by methods which he applies in general to the whole subject. He learns that one subject requires a certain amount of reasoning, another a great exercise of memory, and according to the relative amounts of each, he classifies the subject for future study. But in the mind of the student of beginning physics, the subject does

not find a definite place but immediately assumes an indefinite position, perhaps between mathematics and the descriptive sciences, and he is unable to classify it. Then, as he can find no place for it in his classification, he can find no method of study to apply to it, and he must discover a new one. Hence, his first difficulty. If he has prominent mathematical tendencies he will approach it with the methods of mathematics. Perhaps in physics he finds his first practical application of algebra, geometry and trigonometry, and being attracted by this feature he readily learns those principles of a mathematical nature and tends to interpret all instructions and observations by means of mathematics. Naturally, he soon encounters difficulty in expressing all elementary physical principles or explaining all phenomena in mathematical language, and basing all his conceptions upon methematical formulæ, he finally discovers that he cannot understand some of the simplest problems because of his slight knowledge of the purely physical terms therein. Furthermore, he may be given a mathematical definition of one thing to-day and to-morrow be compelled to define something in an entirely different manner. Hence, he fails to formulate any general principle or rule by which he may approach the various subject matter, and finally resorts to groping in the dark.

Partaking of both mathematical concepts and those of a somewhat philosophical nature, physics presents the greatest difficulties to the pupil of less predominant mathematical tendencies and of little philosophical thought or habit of inquiry. He, more than any other student, is dependent upon some set method of study—too often, perhaps, not his own—the discovery and application of which is a most difficult undertaking. Some studies have been merely the interpretation of what he has seen in the class room with no quantitative relations, with few principles except those based solely on observation, and no explanatory hypotheses embodying things unseen and purely "visionary." Others may have been the study of clear-cut correlated facts based on a few specific principles. Many studies require little past observation, but only a present study with perhaps, opportunity for future corroboration. But none of the methods of approach acquired in these subjects can be applied universally to his physics. If he conclude from theory that some principle should be true he may forthwith meet with some glaring exception. If he base his conclusions upon observed phenomena one day, the next he may be

compelled to take for granted that "a body in motion remains in motion unless acted upon by some external force." These apparent eccentricities and inconsistencies of the subject prove to be more impressive if the pupil has previously formed a conception of physics as either an exact or a descriptive science.

With the pupil of the philosophical or inquiring disposition the methods of physics seem to find greater favor and success, since it is to the gratification of the natural desires for inquiry and investigation that the subject owes its greatest stimulant for successful mastery. Such a pupil has a fund of knowledge and observation on which the teacher can draw. Many difficult principles will, perhaps, find a familiar illustration or example in some phenomenon which has already puzzled him for an explanation. But this class of pupils is comparatively small, and it is not among their number that physics is particularly difficult, while with many of them it is a most fascinating study. However, it seems that the majority of the class do not care for the quantitative relations, but seek rather for qualitative explanations. Since the tendencies of the present elementary teaching of this science are along quantitative lines in consequence of the influence of advanced methods, it follows that the older "Natural Philosophy" was a more popular study than our modern "Physics."

Not only are the methods of physics unusual in their nature, but they are uncertain and limited of application. The subject requires too much theory and mathematics to simply follow observation. The pupil must procede partly by deduction and partly by induction, and he can scarcely know which to use. In the more descriptive sciences he studies largely by inductive methods, and in mathematics by deductive methods, but in physics he is required to use first one and then the other indiscriminately and, apparently, arbitrarily. Hence, to him physics can hardly be considered a science because of the absence of uniform scientific methods as exemplified in most of the others. This same absence of scientific basis in the mind of the pupil is manifest in any attempt by him to define the subject. What is physics? What does it teach? The former can scarcely be answered by any of us to the satisfaction of the average pupil, and the latter would elicit from him the enumeration of a heterogeneous collection of facts and applications gleaned from every subject with which he had come in contact. To the average student physics appears to be a rubbish heap from which other

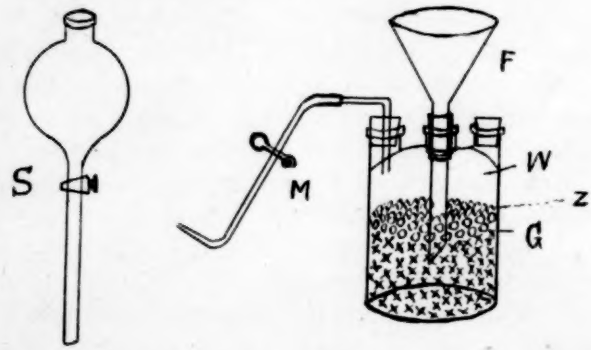
sciences have drawn as much material as was needed to form a complete subject, leaving a large part of everything in an unassorted, unidentified condition. With these or similar conceptions many students begin and end their study of physics. They begin thus because of the dissimilarity between the subject and other known studies, and because of the relations which they dimly perceive ought to exist between it and the other studies. They end thus because they have actually been compelled to learn such a variety of things that they have failed to perceive the relations of these things to the other sciences or to each other.

An attempt at the solution of the difficulties arising from these peculiarities naturally calls forth the questions: Can physics be made more like the other sciences, that is, can we select and apply more of the methods that have proven their efficiency in the other studies? Can the other sciences be made more like physics? In many ways both of these things can be done, and in the latter much has already been done. In mathematics the authors of our text-books, and teachers are continually drawing upon physics for illustrations and problems, so that the application of mathematics to physics is not always a new feature to the beginning pupil. In physical geography much is being done to breach the gap between it and elementary physics, and from the complete articulation of physical geography, a first course in science, and elementary physics in the high schools, much may well be expected. The answer to the first question is not so evident or so simple, since it involves the study of established methods and would, perhaps, suggest changes in many of them, both of which will be left for consideration in subsequent papers. It is the opinion of the writer that physics is pedagogically deficient in a number of desirable characteristics which may be found among the other sciences and that the introduction of some of these and the improvement of others would add greatly to the educational effectiveness of physics among elementary pupils.

AN INEXPENSIVE AUTOMATIC GAS GENERATOR.

By Walter D. Bean,
Chicago Heights, Ill.

For laboratory work in chemistry when working with such gases as hydrogen an automatic generator of the Kipp type is not only a great convenience as compared with the thistle tube and bottle form, in saving time and chemicals, but it is safer. But the high price of the Kipp's generator ($3.70 for the pint size) makes it impossible for each member of the class to have



one for his own individual use. The accompanying drawing illustrates a device that I have found answered the purpose very well. It can be constructed by the pupil himself from the usual apparatus at his disposal. An ordinary glass funnel (F) is fitted, either by stopper or piece of rubber tubing, to the middle opening of a three neck Woulff's bottle (W) (pint size). A delivery tube and pinch cock is fitted to one of the outside openings, and the third which is convenient for filling the bottle, or washing out the salt formed is closed by a cork stopper. The bottle is filled about half full of bits of broken glass tubing or bottle glass (G) to hold the zinc (Z) above the end of the funnel.

A still better but more expensive funnel is one of the separatory type (S), which prevents the acid from spattering when some of the gas escapes through the funnel.

In preparing hydrogen sulphide for qualitative analysis, I prefer to have each student generate his own gas in this way, rather than for all to use a larger, common generator; for then he alone suffers if he leaves the pinch cock open and allows the supply to escape.

THE DECIMALIZATION OF ARITHMETIC.[1]

Very noticeable among the trends in arithmetic is the gradual decimalization. Counting by ten is prehistoric in nearly all parts of the world, ten fingers being the evident explanation. If we had been present at the beginning of arithmetical history, we might have given the primitive race valuable advice as to the choice of a radix of notation! It would then have been opportune to call attention to the advantage of 12 over 10 arising from the greater factorability of 12. Or if the pioneers of arithmetic had been like the Gath giant of 2 Sam. 21:20, with six fingers on each hand, they would doubtless have used 12 as a radix. Lacking such counsel, and being equipped by nature with only 10 fingers to use as counters, they started arithmetic on a decimal basis. History since has been a steady progress in the direction thus chosen (except in details like the table of time, where the incommensurable ratio between the units fixed by nature defied even the French Revolution).

The Arabic notation "was brought to perfection in the fifth or sixth century,"[2] but did not become common in Europe till the sixteenth century. It is not quite universal yet, the Roman numerals being still used on the dials of timepieces, in the titles of sovereigns, the numbers of book chapters and subdivisions, and, in general, where an archaic effect is sought. But the Arabic numerals are so much more convenient that they are superseding the Roman in these places. The change has been noticeable even in the last ten or fifteen years.

The extension of the Arabic system to include fractions was made in the latter part of the sixteenth century. But notwithstanding the superior convenience of decimal fractions, they spread but slowly; and it is only in comparatively recent times that they may be said to be more common than "common fractions."

The next step was logarithms—a step taken in 1614. Within the next ten years they were accommodated to what *we* should call "the base" 10.

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[1] Taken from a book just published: *A Scrap-book of Elementary Mathematics; Notes Recreations, Essays*, by William F. White, Ph.D., State Normal School, New Paltz, New York. 248 pages with frontispiece and 70 diagrams and other illustrations. 12 mo. Cloth binding, gilt top, $1.00 net. The Open Court Publishing Co., Chicago, 1908.

This article is taken from the chapter entitled "Present Trends in Arithmetic," p. 51-54. It had been previously published in part as one in a series of articles by Dr. White in *American Education*.

[2] Cajori, *History of Elementary Mathematics*, p. 154.

The dawn of the nineteenth century found decimal coinage well started in the United States, and a general movement toward decimalization under way in France contemporaneous with the political revolution. The subsequent spread of the metric system over most of the continent of Europe and over many other parts of the world has been the means of teaching decimal fractions.

The movement is still on. The value and importance of decimals are now recognized more every year. And much remains to be decimalized. In stock quotations, fractions are not yet expressed decimally. Three great nations have still to adopt decimal weights and measures in popular use, and England has still to adopt decimal coinage. The history of arithmetic has been, in large part, a slow but well marked growth of the decimal idea.

Those who are working for world-wide decimal coinage. weights and measures—as a time-saver in school-room, counting-house and work-shop—as a boon that we owe to posterity as well as to ourselves—may learn from such a historical survey both caution and courage. Caution not to expect a sudden change. Multitudes move slowly in matters requiring a mental readjustment. The present reform movements—for decimal weights and measures in the United States, and decimal weights, measures and coins in Great Britain—are making more rapid progress than the Arabic numerals or decimal fractions made; and the opponents of the present reform are not so numerous or so prejudiced as were their prototypes who opposed the Arabic notation in the Middle Ages and later. Caution also against impatience with a conservatism whose arguments are drawn from the temporary inconvenience of making any change. Courage to work and wait—in line with progress.

In using fractions, the Egyptians and Greeks kept the numerators constant and operated with the denominators. The Romans and Babylonians preferred a constant denominator, and performed operations on the numerator. The Romans reduced their fractions to the common denominator 12, the Babylonians to 60ths. We also reduce our fractions to a common denominator; but we choose 100. One of the most characteristic trends of modern arithmetic is the rapid growth in the use of percentage —another development of the decimal idea. The broker and the biologist, the statistician and the salesman, the manufacturer and the mathematician alike express results in per cents.

A CASE OF PHOSPHORESCENCE AS A MATING ADAPTATION.[1]

By T. W. Galloway,

James Millikin University, Decatur, Ill.

While engaged in collecting laboratory and museum material at the Bermuda Biological Station during the summer of 1904, I had the opportunity to make some observations on the behavior of a Polychaete Annelid possessing some remarkably definite and interesting mating adaptations. Phosphorescence holds a central place among these adaptations.

Phosphorescence is somewhat common among organisms—as in some bacteria, Protozoa, coelenterates, worms; in certain insects, notably the fire-flies and glow-worms; and in certain abyssal Crustacea and fishes. Much interest has always been manifested in the subject by naturalists, and a large body of literature has arisen.

Physiologically, the following facts may be said to be established beyond reasonable question:

1. Phosphorescence, when present, is associated with the ordinary metabolic processes, and involves the production of some instable chemical substances, in the cell, which on being combined with oxygen emit light. Radźiszewski found that there are a number of such organic products which have this power at ordinary, or slightly higher, temperatures. Among these are certain fats, etherial oils, and alcohols.

2. It always involves the presence and use of free oxygen.

3. It is not accompanied by sensible heat. Experiments by Langley and Very show that in this respect the light of the fire-fly is 400 times as economical as the light of a candle.

4. The process may take place, *in situ,* in the cells in which the materials are produced, or it may occur after the substances have been extruded from the cells. In the first case the oxidation occurs in connection with the nervous and respiratory activities, by which oxygen is brought rapidly to the tissues involved: in the other, oxidation takes place in the air or the water. Phosphorescence is, therefore, not necessarily an *intra vitam* process.

The ecological value of phosphorescence is much less clear. It is not now apparent that these products of katabolism are always, nor even usually, useful to the organism possessing them.

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[1] Read at first meeting of the Illinois Academy of Science, at Decatur, Ill., February 22 ,1908.

It seems probable that we shall have to admit that they are merely by-products of the more usual intra-cellular activities, and that in some instances these by-products have proved of value to their possessors. Neither the mode nor the intensity of the usefulness seems constant.

The Bermuda Biological laboratory, at that time, was located at the hotel "Frascati" on the Flatts Inlet to Harrington Sound. The tide runs freely into and out of the sound by way of this inlet. The worms appear in the waters of this inlet in considerable numbers and with much regularity. I observed two appearances and received notes of a third. The first occurred July 3-7, a period of five days; another took place July 29-31, a period of three days. I was informed that they appeared again on August 23, but I have not complete data concerning this. There is thus an interval of about 25 to 28 days between maxima.

On both occasions when I observed them they appeared daily, throughout the period, within fifteen minutes of the same time—near eight o'clock in the evening, just as dusk was becoming pronounced. It is, of course, the degree of darkness, and not the daily interval, which determines the appearance. The meaning of the monthly periodicity is not clear.

On each evening only a few appeared at first. They gradually increased in numbers so that scores might be seen at once. Then the number gradually diminished, ceasing altogether with a few belated specimens, who kept the curve of frequency practically symmetrical. The display lasted from fifteen to thirty minutes; perhaps twenty minutes on the average.

The daily numbers are subject to the same small beginnings, increase to a maximum, and wane, which is seen on the individual days. The largest number seen at any time was on July 4, the day the party of Americans arrived at the station. It is not clear that this fact has special significance. The number was very much diminished at the demonstration the latter part of July, though they were still sufficiently numerous to be conspicuous. It seems probable that there is an annual, as well as a monthly and a daily maximum.

The female is an inch to an inch and one-half in length, and the male is decidedly smaller, sometimes not more than one-half her length. Both sexes are distinctly phosphorescent, though the male is much less—and much less continuedly—so.

In mating, the females, which are clearly swimming at the sur-

face of the water before they begin to be phosphorescent, show first as a dim glow. Quite suddenly she becomes acutely phosphorescent, particularly in the posterior three-fourths of the body, although all the segments seem to be luminous in some degree. At this phase she swims rapidly through the water in small, luminous circles two or more inches in diameter. Around this smaller vivid circle is a halo of phosphorescence, growing dimmer peripherally. This halo is probably produced by the escaping eggs together with the body fluids which escape with them, as the oxygen in the water meets them. The eggs retain a slight phosphorescence for some time after they are laid.

If the male does not appear, this illumination ceases after 10 to 20 seconds. In the absence of the male the process may be repeated as often as four or five times by one female, at intervals of 10 to 30 seconds. The later intervals are longer than the earlier. Usually, however, the males are sufficiently abundant to make this repetition unnecessary; and the unmated females are rare, if they are out in the open water. One can sometimes locate the drifting female between displays by the persistence of the luminosity of the eggs; but the male is unable to find her in this way.

The male appears first as a delicate glint of light, possibly as much as 10 or 15 feet from the luminous female. They do not swim at the surface, as do the females, but come obliquely up from the deeper water. They dart directly for the center of the luminous circle and they seize the female with remarkable precision, when she is in the acute stage of phosphorescence. If, however, she ceases to be actively phosphorescent before he covers the distance, he is uncertain and apparently ceases swimming, as he certainly ceases being luminous, until she becomes phosphorescent again. When her position becomes defined he quickly seizes her, apparently about the anterior end of the luminous region, and they rotate together in somewhat wider circles, scattering eggs and sperm in the water. The period is somewhat longer on the average than when the female is rotating alone; but it, too, is of short duration.

So far as I have been able to observe, the phosphorescent display is not repeated by either individual after mating. Very shortly the worms cease to be luminous and are lost. Often they give the appearance of sinking out of sight; however, this appearance is negatived by the fact that I have caught both sexes

at once by timing the current and dipping down stream, as much as six or eight feet from the point of latest visible phosphorescence. Often as many as two or three males take part in one mating.

The females caught and examined immediately on becoming luminous are full of eggs. Those caught after three or four displays or after copulation are largely empty of eggs; yet the different segments of one worm will differ widely in this particular. Eggs are caught among the setæ and at any other points where they can be held.

The phosphorescence of the female is clearly attendant upon egg-laying, beginning only when the eggs begin to emerge into the water. It is possible, however, that the first glow is premonitory and internal. When disturbed in confinement, after mating, both males and females may be aroused to momentary phosphorescent responses for a period of an hour or more. These latter responses seem to be internal, but of this I am by no means sure.

The phosphorescene of the male, so far as I could observe, has no meaning in the process. It probably represents merely the possession by both sexes of a form of metabolism that is especially valuable in one of them. Its smaller degree of development in the male suggests its inutility. Of course it is conceivable that the luminous flashes of the male, if perceived by the female, may act to lengthen her luminous period. I was able to get no evidence that this was true.

There are here several coincident points of indubitable sexual adaptation, which are interesting and effective and help to insure the union of the sperm and ova: (1) The concentration of the ripening of eggs and sperm into a few days of the month and their coincident deposition within twenty minutes in the twenty-four hours, with the coming of dusk. This phenomenon is common in some degree, to many organisms. (2) The repeated periods of luminosity of the female, serving as a lure to the males. (3) The sexual dimorphism in the character of the phosphorescence of the two sexes which serves as identification marks. (4) The fact that the females swim at the surface while the males come from beneath enables the male to locate the female with much greater precision than if he, too, were at the surface. Her coming to the surface not merely localizes her movement in a plane, but makes the oxidation more complete and apparent. The absence of either of these four adaptations would reduce the certainty of the union of the sexual cells.

Nothing is known of this worm or its habits except what is revealed by this one glimpse of its life at mating time. It has never been taken, so far as I have been able to discover, except during these evolutions, and even these would be wholly unknown except for this momentary phosphorescence which accompanies the maturation of the sexual cells. Whether it is a burrowing type which comes to the surface only at this time, or a pelagic type swept in by the tides, we are not sure. Occasionally Foraminifera are found caught among the setæ; this suggests that it may have its home on the bottom.

Naturally the facts above stated make the worm a favorable organism for the study of embryology. Abundance of material can be had, and the moment of fertilization can be approximated with much closeness; two items quite essential in such studies. The following schedule of some of the early developmental stages may be interesting to some of you:

1. Eggs fertilized about 8 o'clock.
2. Ciliated and rotating blastulas at midnight (4 hours).
3. Gastrulation occurred numerously between the fourth and sixth hours.
4. Eye spots developed in ectoderm in 6 to 7 hours.
5. The ectodermic invaginations to form mouth and anus about 7 hours.
6. Shows signs of metameric segmentation in posterior region of trochosphere about the eighteenth hour.
7. Bristles of the dorsal bundles begin to be apparent 29-30 hours.

Read at first meeting of the Illinois Academy of Science, at Decatur, Ill., February 22, 1908.

A LINEAR EXPANSION APPARATUS.[1]

By Clarence M. Hall,

Central High School, Springfield, Mass.

A simple, inexpensive apparatus for measuring the linear coefficient of expansion of brass, which has given good results in students' hands is here described:

A quarter inch brass tube about three feet long is mounted on a wood base as shown in the figure. One end of the tube passes

[1]The cut is a representation of the linear expansion apparatus described in this article and was kindly loaned by the makers of the apparatus, the Cambridge Botanical Supply Co.

easily through a screw eye, projecting about one inch; the other end fits snugly without backlash, down over a taper pin which passes through a small hole drilled in the tube. This last end of the tube should project over the end of the wood base, to prevent the steam used from wetting the base.

About one-quarter inch from the screw eye, toward the taper pin, is made a prick punch mark in the side of the tube. Into this mark or dent fits one of the conical ends of a short steel rod, while the other end of this rod, also conical, fits into a prick punch mark in a brass piece screwed to the wood base. These conical points are hardened and ground.

Through this steel rod is riveted a long steel index or pointer, which moves over a paper millimeter scale on the base.

In use, the tube is lifted up off the taper pin and the index is then removed, by sliding the tube out of the screw eye.

The distance from the taper pinhole to the prick punch mark is the cold length of the brass. The short arm of the lever is measured by a vernier beam caliper, measuring to one-tenth millimeter, by calipering the outside dimension of the extreme points. The long arm is the distance from the end of the index wire back to the point of the rod nearest it.

The steam temperature is obtained from the barometer reading.

The apparatus is assembled and steam led through it from a boiler, by a tube slipped over the end of the brass tube passing through the screw eye, and in a few seconds the expansion is complete and the index may be read.

The following data were obtained by a student with the above apparatus:

Barometer .... 75.9 cm.
Temperature of room, ... 19.0° C.
Length of tube, ... 83.8 cm.
Length of short arm of lever,.............. 3.5 cm.
Length of long arm of lever,............... 30.5 cm.
Reading of index at temperature of room,..... 1.22 cm.
Reading of index after expansion was complete, 2.34 cm.

The above data give by calculation, 0.0000188 for the coefficient.

THE POSITION OF BIOLOGY IN THE HIGH SCHOOL COURSE.

By Willard N. Clute,

Joliet, Ill.

However much teachers may differ as to the subject matter and method of presenting a course in any given science, they are likely to agree in one thing, namely, that the particular science they are teaching should be given in the last year of the high school course. It is but natural that every teacher should desire the more mature pupils, but even a hasty consideration of the subject must show that some sciences are better fitted than others for presenting to pupils in the first years of the high school. There is an evolution of perception as in other things and if that teaching is the most effective in which the subjects are presented in logical order, the least complicated first, surely the same thing is true of related sciences.

In many lines of high school work this principle is recognized and the sequence definitely settled. In mathematics, for instance, arithmetic precedes algebra and the latter geometry. while physics, surveying, trigonometry, etc., must follow these subjects to be either understandable or useful. Chemistry, on account of the careful manipulation required, the problems involved, and the stock of information in other lines necessary, is well entitled to its place in the last school year.

In my opinion a similar sequence may be found in the natural sciences beginning with physiography and running through botany and zoölogy and I am firmly convinced that no community can lay claim to being an educated one in which each child has not had at least a year of each of these sciences. To put botany before physiography, however, is to my mind wrong, if we consider the relations of these two sciences to each other and to the general course of study. By nature botany is almost wholly a laboratory and field study, calling, when properly taught, for perceptions and reasoning powers beyond the ability of first year pupils. Physiography, on the other hand, depending more upon books and maps, is more directly related to the geography of the grades, in fact is a direct continuation of it. Standing half-way betwen book study and strict laboratory work it is the best of all studies with which to introduce pupils to the laboratory method and the use of field trips. Physiography pupils carry over into

botany along with the ability to study materials at first hand, a large stock of facts about the soil, the air and the rocks that will be of great service to them in the new study, to say nothing of other facts which they can use in physics and allied subjects. In a similar way, botany, less complex than zoölogy, but dealing with the same general principles applied to a different set of objects, should precede and pave the way for that study.

In passing it may be asked why we who are teaching the natural sciences should be satisfied with a mere nine or ten months devoted to each, when Latin, French, German, and various other studies, certainly less useful to the average man, run through the full four years' course. Doubtless every good teacher thinks his own subject of paramount importance, but allowing for this prejudice, we may still ask if there is any good reason why we, a great nation whose prosperity depends primarily upon agriculture, the mines, and the forests, should give but a single year to a study of matter related to these things when we devote four years to various languages that at best can have no such direct bearing upon life. My plea is not for less language work, but for more science. A year's work in physiography could well be followed by another in applied geology, while botany, only the fundamentals of which can be taught in a single year, could—or shall we say, should—be followed by courses in elementary agriculture, gardening, forestry, and a study of the flora of the region especially with an eye to its ecological aspects. Zoölogy, still more condensed than botany, if limited to a year's work, should go on to a study of animals in their economic aspects and a study of the fauna. If botany is to be introduced into the first year of the high school, well and good, but in this event, let us have four years of botany and turn out pupils fairly well acquainted with the world they live in.

PROBLEM DEPARTMENT.

IRA M. DELONG,

University of Colorado, Boulder, Colo.

Readers of the Magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to Ira M. DeLong, Boulder, Colo.

Algebra.

98. *Proposed by W. T. Brewer, Quincy, Ill.*

Between 6 and 7 o'clock, how far is the minute hand ahead of the hour hand when they are making equal angles with a line drawn from 10 to 4, both angles on the same side of the line?

I. Solution by Ernest Crutcher, Salida, Colorado.

Let C be the center of the dial. The angles 10, C, 7 and 7, C, 4 being right angles, are equal; and it is easily seen that the minute hand must be a distance past 7 equal to the distance of the hour hand before seven. Let x = distance covered by minute hand after six; then $\frac{x}{12}$ = distance covered by the hour hand after six, and $x - \left(x - \frac{x}{12}\right) = 35$, whence $12x - 60 + x = 420$, and $x = 36\frac{12}{13}$. The distance between the hands is $2(36\frac{12}{13} - 35) = 3\frac{11}{13}$ spaces.

II. Solution by Frank S. Heinaman, Youngsville, Pa.

Let x = number of minute spaces from 4 to the minute hand; it will also equal the number of minute spaces from 10 back to the hour hand. Then $20 + x$ = number spaces the minute hand moves over and $20 - x$ = number of spaces the hour hand moves over.

$\therefore 20 + x = 12(20 - x)$, and $x = 16\frac{12}{13}$.

Then the minute hand is $6\frac{12}{13}$ spaces past six, the hour hand is $3\frac{1}{13}$ spaces past six, and the minute hand is $3\frac{11}{13}$ spaces in advance of the hour hand. The time is $36\frac{12}{13}$ past six.

Geometry.

100. *Proposed by E. L. Brown, M.A., Denver, Colo.*

Inscribe a square in a given quadrilateral.

I. Solution by Orville Price, Denver, Colorado.

Let ABCD be the given quadrilateral, and assume the perpendicular distance from B upon DC greater than the perpendicular distance from A upon DC. Produce CD and BA to meet in E; from B draw BR perpendicular to DC and with BR as one side construct a square BRST, R and S lying on DC. Let ET meet BC in K. With K as a vertex construct a square KLMH, L and M lying on DC. The latter is the required square. The equality of the sides is easily established from the similar triangles EHK, EBT and EKL, ETS. [NOTE.—If the distance from A to DC is greater than from B to DC then K should be taken as the intersection of ET with AD.—ED.]

II. Solution by H. E. Trefethen, Kent's Hill, Maine.

Let the angles A and B at the base of the quadrilateral be acute and

C and D respectively the adjacent vertices, of which C is the more distant from AB. From C parallel to AB (and in the same direction) draw CP equal to the distance from C to AB. Join P to A. AP cuts BD or CD at some point Q. Draw QR parallel to AB meeting AC at R. QR is one side of a square whose opposite side is on AB. For the triangles APC and AQR are similar. But the base and altitude of APC are equal by construction. Hence QR is equal to its distance from AB.

(1) If the given quadrilateral has only one acute angle, there may be one solution or there may be none.

(2) If it has two acute angles, there is one solution at least and there may be two.

(3) If it has three acute angles, there are at least two solutions and there may be three.

101. *Proposed by H. E. Trefethen, Kent's Hill, Maine.*

The altitude of a triangle is 24, the bisector of the vertical angle is 25, and the bisector of the base is 40. Construct the triangle and compute the sides.

Solution by H. C. Whitaker, Ph.D., Philadelphia Pa.

On an indefinite straight line take any point D and erect a perpendicular DC equal to the given altitude. With C as a center and the given bisector as radius cut the first line in the point I, and with the same center and radius equal to the given median cut DI in E. At E erect a perpendicular to DE to meet CI prolonged in F, a point on the circumcircle of the required triangle. Bisect CF in H and draw a perpendicular through H meeting EF in G, the center of the circumcircle. With G as a center and GC as radius strike the line DE in A and B. Then ABC is the required triangle.

We have, CD = 24, CI = 25, CE = 40. In triangle CDE, DE = 32, in triangle CDI, DI = 7; therefore IE = 25. In the similar triangles CDI and FEI, EF = $\frac{600}{7}$ and FI = $\frac{625}{7}$; by addition, FC = $\frac{800}{7}$. In the similar triangles FCA and FAI, FA = $\frac{500}{7}\sqrt{2}$ and in triangle FEA, EA = $\frac{100}{7}\sqrt{2}$ and base AB = $\frac{200}{7}\sqrt{14}$. AI = AE − IE = $\frac{100}{7}\sqrt{14} - 25$, BI = $\frac{100}{7}\sqrt{14} + 25$. AC = $20\left(\frac{8}{\sqrt{7}} - \sqrt{2}\right)$ by using similar triangles FCA and FAI. From triangles FBI and FCB, CB = $20\left(\frac{8}{\sqrt{7}} + \sqrt{2}\right)$, and from the similar triangles FEI and FHG, the radius = $\frac{1250}{21}$.

Miscellaneous.

102. *Proposed by I. L. Winckler, Cleveland, Ohio.*

Find the limit of $(\cos ax)^{\csc^2 bx}$ when $x = 0$.

I. Solution by G. B. M. Zerr, Ph.D., Philadelphia, Pa.; A. J. Lewis, Denver, Colo.; Orville Price, Denver, Colo.; Geo. W. Hartwell, New York; and H. E. Trefethen, Kent's Hill, Maine.

Let $u = (\cos ax)^{\csc^2 bx}$, then

$$\log u = \frac{\log \cos ax}{\sin^2 bx} = \frac{f(x)}{\phi(x)};$$

$$\frac{f'(x)}{\phi'(x)}=-\frac{a\tan ax}{b\sin 2bx}=\frac{0}{0}, \text{ when } x=0.$$

$$\frac{f''(x)}{\phi''(x)}=-\frac{a^2\sec^3 ax}{2b^2\cos 2bx}=-\frac{a^2}{2b^2}, \text{ when } x=0. \text{ Therefore, } u=e^{-a^2/2b^2}.$$

II. Solution by W. L. Malone, Fern Hill, Wash.; H. E. Trefethen, Kent's Hill, Me.; and H. C. Whitaker, Ph.D., Philadelphia, Pa.

Let $y=(\cos ax)^{\csc^2 bx}$, then $\log y=\dfrac{\log\cos ax}{\sin^2 bx}=\dfrac{-a^2x^2/2+a^4x^4/8\ldots.}{b^2x^2-b^4x^2/3\ldots\ldots\ldots}$

$=$(dividing by x^2 and taking the limit when $x=0$)$-\dfrac{a^2}{2b^2}$. Therefore, $y=e^{-a^2/2b^2}$.

Credit for Solutions Received.

Algebra 92. H. C. Feemster. (1)
Geometry 93. Walter L. Brown, H. C. Feemster. (2)
Geometry 94. M. L. Constable, H. C. Feemster, Jno. A. Hodge. (3)
Geometry 95. M. L. Constable, H. C. Feemster, Geo. W. Hartwell. (3)
Trigonometry 96. H. C. Feemster, Alfred Kerndt, Orville Price. (3)
Algebra 98. Walter L. Brown, Wm. B. Borgers, W. T. Brewer (2 solutions), Ernest Crutcher, Neil Davenport, H. C. Feemster (2 solutions), Geo. W. Griswold, Jr., A. M. Harding, R. P. Harker, Geo. W. Hartwell, Frank S. Heinaman, Alfred Kerndt, J. F. Lawrence, A. J. Lewis, W. L. Malone, Edward Morgan, Orville Price, A. W. Rich, O. R. Sheldon, H. E. Trefethen, F. E. Tuck, H. C. Whitaker, I. L. Winckler, G. B. M. Zerr. Also two incorrect solutions. (28)
Geometry 100. Walter L. Brown, Geo. G. Brower, H. C. Feemster, A. M. Harding, A. J. Lewis, Orville Price, A. W. Rich, H. E. Trefethen, Charles S. Webb, I. L. Winckler, G. B. M. Zerr (2 solutions). Also two incorrect solutions. (14)
Geometry 101. Walter L. Brown, H. C. Feemster, Geo. W. Hartwell, A. J. Lewis, L. E. A. Ling, W. L. Malone, Orville Price, A. W. Rich, H. E. Trefethen, H. C. Whitaker, I. L. Winckler, G. B. M. Zerr. (12)
Miscellaneous 102. Geo. W. Hartwell, J. F. Lawrence, A. J. Lewis, W. L. Malone, Orville Price, H. E. Trefethen (2 solutions), H. C. Whitaker, I. L. Winckler (2 solutions), G. B. M. Zerr. (11)
Total number of solutions, 77.

PROBLEMS FOR SOLUTION.

Algebra.

108. *Proposed by Lloyd Holsinger, Peoria, Ill.*

If $ax+by+cz=0$ and $\dfrac{a}{x}+\dfrac{b}{y}+\dfrac{c}{z}=0$, prove that $ax^3+by^3+cz^3=-(a+b+c)(y+z)(z+x)(x+y)$.

109. *Proposed by J. O. Mahoney, Dallas, Texas.*

How many angles are formed by lines connecting n points in a plane? How many diagonals may be drawn in an ordinary figure of n sides?

Geometry.

110. *Proposed by W. L. Malone, Fern Hill, Wash.*

Through two given points draw a circle tangent to a given circle.

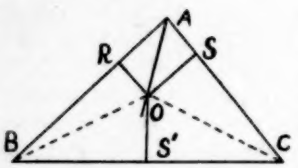
111. *Proposed by R. C. Shellenbarger, Yankton, So. Dak.*

Find the radius of a circle having given the length and height of an arc in linear units.

107. *Proposed by Walter L. Brown.*

Find the fallacy in the following argument: "All triangles are isosceles."

Proof: Bisect the vertical angle A by the line AO, and let this line meet the perpendicular bisector of BC in O. Draw OS perpendicular to AC and OR perpendicular to AB. Connect OB, OC. Then RO = OS, OB = OC, angle BRO = angle CSO being right angles, and therefore RB = SC. Likewise AR = AS. By addition it now follows that AB = AC.



Applied Mathematics.

112. *Proposed by G. B. M. Zerr, Ph.D., Philadelphia, Pa.*

The specific gravity of copper is 8.8, of aluminum 2.5. The price of copper is 16 cents per pound, of aluminum 35 cents per pound. The conductivity of copper to aluminum = 100 : 65. Which is the cheaper for electrical conductors?

THE TEACHING OF GEOMETRY. A WAY OUT.

By Margaret A. Gaffney,
Whitman, Mass.

For several years I have been a more or less astonished reader of the discussion of the material and methods of high school geometry. At last I am driven to cry out with the satirist:

"Semper ego auditor tantum? Nunquamne reponam
Vexatus toties rauci Theseide Codri?"

The opposing partisans of the non-rigorous and the rational contend for different ways of presenting what they seem to regard as one subject. Whereas the truth appears to be that what passes under the name of geometry is a combination of two distinct subjects, namely, experimental or intuitional geometry and rational geometry, differing in material, development, and application. Both are too valuable for either to be allowed to oust the other.

The proposed way out of the conflict is just this. Admit that there has been a disadvantageous confusion of two distinct things, separate

them, giving to rational geometry preferably a new name; then deal with each according to its nature and use. Thus, in the allotted time, let experimental or intuitional geometry be taught in the way that will soonest and easiest put its students in possession of the largest body possible of the mathematical truths which have application in physical science and mechanics. Let its students be taught truly, so far as they go, measurement and the use of instruments of measurement. Let it be a discipline toward delicacy and sureness of eye and hand. Let the end sought be practical, accurate results, not logical impeccability; a good and worthy end it is, too.

But this admission should not give offense to rational geometry, nor detract in the slightest from its claim to a place, say, in the last year of the high school course. Indeed, it may well be asserted that rational geometry is even more important than the experimental, since there is no condition of life where its teachings are not in place. But to profit most largely, its students should be left in no doubt as to what they are about. They are no longer engaged chiefly in the acquirement of mathematical facts. Material precision is no longer of consequence. On the contrary, they are being introduced to a study of the working of their own minds, through which they may come to get some skill in analyzing the origin of their own mental content, distinguishing between what comes to them through intuition, perception, authority, and deduction; some notion of the place of hypothesis in science; and, greatest of all, the habit of dealing with the problems of every-day life with some approach to the methods of rational beings.

If geometry could be thus separated and organized, the student of experimental geometry need not, for instance, prove that all right angles are equal; and the student of rational geometry would never think of exclaiming, when occupied with that same theorem, "Why, any fool knows that!"

Now, if our mathematical masters would set themselves to differentiate and illuminate for us the nature, aims, and values of these two distinct subjects, or, at least, these two very different phases of the same subject, instead of contending for this or that method of presenting both as one, many teachers, themselves without authority or right of initiative, would be helped and would be thankful, while now they are too often like "the hungry sheep," who "look up and are not fed."

NOTICE.

Will any one who has extra copies of the report of the Committee on Geometry which was read at the St. Louis meeting, kindly send them to Miss Mabel Sykes, South Chicago High School, Chicago, Ill.?

A COMMUNICATION.

DETROIT, MICH., February 13, 1908.

In one of the late numbers of SCHOOL SCIENCE AND MATHEMATICS I noticed a demonstration in Geometry as prepared by a high school pupil.

I am venturing to send a problem from our trigonometry text and the solution as worked out by William Cogger. I can certify that the work is entirely his own. Very truly yours,

GERTRUDE L. ROPER.

In each of two triangles the angles are in G. P. The least angle of one of them is three times the least angle of the other, and the sum of the greatest angles is 240°. Find the circular measure of each of the angles.

Lyman and Goddard, "Plane and Spherical Trigonometry," Page 28, Problem 24.

Let $x =$ smallest angle in one triangle
and $y =$ ratio of angles.
Also $z =$ ratio of angles in other triangle.
Then—

$$x + yx + y^2x = 180^\circ$$
$$3x + 3zx + 3z^2x = 180^\circ$$
$$3z^2x + y^2x = 240^\circ$$
$$\frac{180^\circ}{1+y+y^2} = \frac{180^\circ}{3+3z+3z^2} = \frac{240^\circ}{3z^2+y}$$

Solving first and third

$$9z^2 + 3y^2 = 4 + 4y + 4y^2$$
$$9z^2 = 4 + 4y + y^2$$
$$(a)\quad 3z = 2 + y$$

Solving second and third.

$$9z^2 + 3y^2 = 12 + 12z + 12z^2$$
$$3y^2 = 12 + 12z + 3z^2$$
$$(b)\quad y = 2 + z$$
$$(a)\quad 3z = 2 + y$$
$$z = 2$$
$$y = 4$$
$$x + 4x + 16x = 180$$
$$x = \frac{180^\circ}{21} = \frac{60^\circ}{7}$$

$\therefore$ Angles in one triangle are

$$\frac{60^\circ}{7}, \frac{240^\circ}{7}, \frac{960^\circ}{7}$$

and angles in other triangle are

$$\frac{180^\circ}{7}, \frac{360^\circ}{7}, \frac{720^\circ}{7}$$

SCIENCE QUESTIONS.

By Franklin T. Jones,
University School, Cleveland, Ohio.

Propose questions for solution or discussion.
Send in solutions of questions asked.
Send examination papers in the sciences.

Proposed by J. C. Packard, High School, Brookline, Mass.

(For the teacher of physics—to test the clearness of his own conception concerning the unit of heat.)

How large a square cut from the paper on which this magazine is printed would be required—upon a rough estimate—to produce one calorie of heat when burning in the open air?

Suggested for discussion by Wm. A. Hedrick, McKinley Manual Training High School, Washington, D. C.

A student can *on examination* (or otherwise) enter more than forty of the leading colleges or universities, including Cornell, Chicago, Swarthmore and the state universities, *unconditioned*, as a candidate for the A.B. degree, without any preparatory Latin or Greek. From more than fifty, including Bryn Mawr, Wellesley, Bowdoin, Cornell, New York and Minnesota, he can graduate with the same degree without taking any Latin or Greek in college.

Should not some of this time thus placed at the student's disposal be devoted to additional courses in science in the secondary school?

Proposed by Fredus N. Peters, Central High School, Kansas City, Mo.

What are the "Fundamentals of Chemistry" for secondary schools?

From a Cornell University entrance examination.

How would you prove that the composition of water is expressed by the formula H_2O?

[Kindly try this question with your best pupils and see how satisfactory the answers obtained are. Send in results to the Editor.]

Proposed by Alpheus W. Rich, Highland Military Academy, Worcester, Mass.

Are the terms—anode, cathode, +pole or electrode, —pole or electrode, +plate and —plate—as used in our text-books confusing? Authors apparently do not agree.

Are the terms used in a loose way? If so, ought they not to be avoided as far as possible?

Does +pole mean cathode in a primary battery and anode in an electrolytic cell?

In the March, 1908, number of this journal the following question was asked:

A liquid stands to a depth h in a vessel connected by a stop-cock with another vessel of equal volume and like shape standing at the same level.

The potential energy of the liquid is $mgh/2$.

The stop-cock is opened so that the liquid stands to a depth $h/2$ in each vessel.

The potential energy is now $mgh/4$.

What becomes of the 50 per cent of energy which has ceased to be potential? (Crew—Elements of Physics, page 107.)

Solution by Otto M. Smith, High School, Springfield, Mo.

Potential energy of whole liquid $= mgh/2$. After stop-cock is opened the potential energy $= mgh/4$. Therefore the energy that has ceased to be potential $= mgh/4$, which is equal to the kinetic energy.

Consider that the lower half of the liquid remains fixed and the upper half is movable. Then the mass of the moving liquid $= m/2$. The center of gravity of this mass has changed from $3h/4$ to $h/4$, namely by $h/2$.

Substituting in $v^2 = 2gs$, $v^2 = 2gh/2$.

Then K. E. $= \frac{1}{2} \times m/2 \times 2gh/2 = mgh/4$.

Therefore 50% of potential energy has been transformed into kinetic energy, since K. E. $= mgh/4$ and P. E. also $= mgh/4$.

NOTES.

Would a General Proof Be An Improvement?

Theorem. If two quantities X and Y are so related that equal parts x of X correspond to equal parts y of Y, then any two X's are proportional to the corresponding Y's.

Proof I. When X and X′ are commensurable.

If $X = mx$ and $X' = m'x$, since X corresponds to Y $(= my)$ and X′ to Y′ $(= m'y)$ $X/X' = m/m' = Y/Y'$. Q. E. D.

II. When X and X′ are incommensurable.

Divide X′ into m' equal parts and apply one of them as many times to X as it is contained, say m times with a remainder $R < X'/m'$.

Let X'' $(= m\,X'/m')$ correspond to Y''.

By I, $X''/X' = Y''/Y'$. The denominators are constant, and the numerators are variables having X and Y as their limits respectively, as m' is indefinitely increased.

Since if two variables are always equal their limits are equal, $X/X' = Y/Y'$. Q. E. D.

T. M. Blakslee, Ames, Iowa.

The Method of Multiplying a Multiple of 7 by 43.

In the March number of this journal, page 253, Mr. Dwight S. Wiseman describes a process for finding the product of 43 by any multiple of 7. A rule for the process may be formulated as follows:

Divide the multiple by 7; then, to find the product, proceed thus:

a. For a one-figure quotient, annex the quotient preceded by a cipher to three times the quotient.

b. For a two-figure quotient, annex the quotient to three times the quotient.

c. For a many-figure quotient, annex the tens and units of the quotient to three times the whole quotient increased by that part of it which is above the tens' figure.

After the process is once clear, the foregoing three phases of the rule may be merged as follows:

Annex the quotient considered as units and tens of the product to three times the whole quotient considered as hundreds, thousands, etc., of the product.

To explain the rule, let $7x$ be the multiple; then 43 times $7x$ is $301x$; or, $43 \times 7x = 301x = 300x + x = 100\ (3x) + x$.

The last form clearly shows that the quotient x is the units and tens of the product, while three times the quotient is the hundreds, etc.

Similar algorithms may be devised by multiplying $(100k + 43)$ by $7x$, or $(100k + 67)$ by $3x$, etc.; in fact, the number of them is infinite, without probably any one of them being worth remembering except as puzzles.

WM. B. BORGERS, GRAND RAPIDS, MICH.

I. If $7a$ be the multiple of 7, $43(7a) = 301a = 300a + a$.
e. g., if $a = 5$, $43(35) = 1500 + 5 = 1505$.

II. If $43b$ be the multiple b, $43b(7a) = 300ab + ab$.
e. g., if $a = 9$ and $b = 2$, $86(63) = 5400 + 18 = 5418$.

III. If instead of $43b$ we have $100c + 43b$, it is evident that in I, $700ac = 700c(a)$ is to be added, and in II, $700c(ab)$ is to be added.

T. M. BLAKSLEE, AMES, IOWA.

The rationale may be stated as follows:

The product to be formed will consist of three factors, 43, 7, and quotient obtained by dividing the given number by 7. The product of the two factors 43 and 7 is 301. Multiplying the quotient by 1 and by 300 completes the operation. In multiplying by 143, the partial product is 301 + 700, or 1001, etc., etc.

A variety of similar methods may be devised to suit special cases, as for instance, required to multiply by 67 a number divisible by 3. Suppose we have 39. Dividing by 3 gives 13. Taking this as the tens and units, and multiplying by 2, which gives 26 for the next two places, we have 2613 as our final product.

Other examples might be mentioned, but we use a great number of them unconsciously. Factoring in order to discover more convenient combinations for mental multiplication and division is of frequent use, although not generally taught in the schools. Why not make more of it in the lower grades? Respectfully,

MARTIN L. FLUCKEY, SHREVE, OHIO.

[An explanation of this method was also received from C. H. Ratcliff, Grand Island, Nebraska.]

ARTICLES FROM CURRENT MAGAZINES.

Astrophysical Journal, March, 1908: "The Absorption of Some Gases for Light of very Short Wave Lengths," by Theodore Lyman; "The Function of a Color-Filter and 'Isochromatic' Plate in Astronomical Photography," by Robert James Wallace; "On the Spectrum of Calcium," by James Barnes.

Condor for March-April: "Life History of the California Condor, Part III—Home Life of the Condors," William L. Finley; "Notes on the Rhea or South American Ostrich," Samuel Adams; "Observations on the Nesting Habits of the Phamopefla," Harriet Williams Myers.

Biological Bulletin for March: "A Statistical Study of Mitosis and Amitosis in the Entoderm of Fasciolaria tulipa var distans," O. C. Glaser; "The Clasping Organs of Extinct and Recent Amphibia," Roy L. Moodie.

Bird-Lore for March-April: "The Home Life of the American Egret," Frank M. Chapman; "The Background of Ornithology," Spencer Trotter; "The Nest in the Gutter," Gilbert H. Trafton.

Forestry and Irrigation for March: "Annual Meeting of the American Forestry Association," Mrs. Lydia Adams-Williams; "Constitutionality of the Appalachian Bill," Harvey N. Shepard; "The President's Annual Address," Hon. James Wilson, illustrated; "Improvement of Our Heritage," Gifford Pinchot, illustrated; "Annual Report of the Board of Directors for the Year 1907," illustrated; "Propriety and Need of Federal Action," Hon. Hoke Smith; "Work in a National Forest," Charles H. Shinn.

Nature-Study Review for February: "Relation of Science and Nature-Study," M. A. Bigelow; "Children as Naturalists," H. N. Loomis; "Practical Nature-Study with Birds," G. H. Trafton; "Nature-Study and High-School Science," H. Brownell.

Photo-Era for March: "The Fourth American Photographic Salon, Foreign Section," Wilfred A. French, Ph.D.; "How to Color Photographs," B. I. Barrett; "Commercial Photography for the Contractors' Needs," John P. Slack; "Preparing Paper for Sepia Printing with the Salts of Iron and Silver," A. J. Jarman; "Some Hints on the Toning of Bromide Enlargements," George H. Scheer, M.D.; "Profitable Camera Work for Women," I. W. Blake.

Photo-Era Magazine for April: Seven out of the twenty-three beautiful pictures which adorn the April issue of *Photo-Era Magazine* demonstrate conclusively that there are "Pictorial Possibilities in High-Speed Work." C. H. Claudy's article on that subject adds strength to the pictorial assertion. The other illustrations include some exceptional portraits, marines by William Norrie, the famous Scottish photographer, and a beautiful study of the nude by Benjamin. The letter-press includes the first of a series of papers, "Disadvantages of Working in Miniature," by David J. Cook; "Architectural Telephotography," by Maurice Houghton; "Photographing Statues," by Richard Percy Hines; "Contrasty Negatives and the Remedies," by James Thomson; "How to Color Photographs," by B. I. Barrett; "Reducing and Clearing Platinotypes," by G. R. Ballance. In "The Crucible" Phil M. Riley describes how Lumiere color-plates are amenable to stand development like ordinary dry-plates.

Popular Astronomy for April: "Outline of the New Theory of Earthquakes," T. J. J. See; "Charles Augustus Young," John M. Poor.

School World for March: "The Lantern in Class Teaching of Geography," by B. B. Dickinson, M.A., F.R.G.S.; "Notes on Geometrical Progressions to Infinity," illustrated, by G. E. Crawford, M.A.; "Some New Scientific Apparatus," illustrated, by G. H. Wyatt, B.Sc., A.R.C.Sc.; "Manual Instruction in Wood, a Course for Secondary Schools, II," illustrated, by J. W. Riley; "The Order in Which Scientific Ideas Should be Presented," by Prof. H. A. Miers, D.Sc., M.A., F.R.S.

Scientific American for March 7: "Progress of the Catskill Water Supply, II," "The British Navy of To-day." For March 21: "Water Vapor on Mars," Dr. S. A. Mitchell; "The Fourth Dimension Simply Explained," J. Springer.

Scientific American Supplement for March 14: "Ultra-Filtration, a proof of the Existence of Molecules," Dr. Bechhold. For March 21: "A New Kind of Wheat," Charles Christadoro; "The Basis for a New Geology," H. W. Pearson; "Suns and Nebulæ, I," illustrated, Svante Arrhenius. For April 4: "The Fortress of the Mole," W. P. Pycraft; "The Flower Doctor," S. L. Bastin.

FUNDAMENTALS IN PHYSICS.

A Report of a Committee of the Northeastern Ohio Association of Science and Mathematics Teachers.

The committee of the Northeastern Ohio Association of Science and Mathematics Teachers, appointed at the fall meeting, 1907, beg to submit the following report on Fundamentals in Physics.

It will be noted—

(1) That this report *does not deal at all with methods of teaching Physics* nor

(2) With the mode or order in which the subject is to be presented but

(3) *Lays emphasis on results only,* assuming

(4) That each teacher will select that order of topics and method of presentation best adapted to the conditions under which he is working, and

(5) That he will exercise due care in cultivating scientific habits of thought and proper respect for accuracy.

The report has three main divisions—

(1) General Statement,

(2) Fundamentals in Physics,

(3) Related Subject Matter.

Franklin T. Jones, Chairman, University School,
Dayton C. Miller, Case School of Applied Science,
Harold B. Reed, East High School,
Geo. R. Twiss, Central High School,
Frank P. Whitman, Adelbert College.

Cleveland, Ohio, March 21, 1908.

I. General Statement.

1. Many of the difficulties encountered in the teaching of Physics, and many of the deficiencies in the results attained are caused by the attempt to teach too many things, and to teach all things with equal thoroughness.

2. A student, after having passed through the first year's course in Physics, should know thoroughly a few things of fundamental importance and general application. These concepts, which the student should master so that he shall be able to reproduce them at will, and to apply them in a reasonable degree to specific cases, will, for the purposes of this report, be termed "fundamentals."

3. Besides the more intimate knowledge of the fundamentals, the student should have acquired a fair degree of familiarity with a considerable number of other concepts, of less general application and less relative importance. Such concepts include many phenomena more or less closely related to the fundamentals, some specific relations of phenomena to one another, some of the generally accepted theories, and some of the most familiar practical applications, especially those most closely related to the everyday life of the average citizen. For the purposes of this report, the concepts thus described will be styled "related subject matter."

The related subject matter should be used to furnish a background, or pictorial setting for the fundamentals; and will serve to give the student a set of mental images which he may use in his thinking, and which will tend to give him a proper sense of proportion in judging the relative importance of the fundamentals.

4. The fundamentals include what should be thoroughly taught to all pupils, but the amount and choice of related subject matter, and the methods and order of teaching both fundamentals and related subject matter should be entirely in the hands of the individual teacher. The teacher should use related subject matter according to his judgment and experience to secure the best results in view of the demands and facilities of the community and the needs of individuals and classes.

5. Study of a standard text with illustrative and laboratory experiments in sufficient quantity to make the knowledge of fundamentals real is implied in the content of this report.

6. It is also implied that where the fundamentals involve quantitative relations, the student should be able to solve simple numerical problems in these relations; but such problems should be free from puzzles and complications that are purely mathematical, and should adhere as closely as possible to concrete notions of real things.

7. Examination questions should be framed with the object of testing knowledge of the fundamentals, and ability to draw conclusions in accordance therewith. They should not demand specific knowledge of isolated facts not named among the fundamentals.

II. Fundamentals in Physics.

Mechanics.

1. Meaning of the terms—mass, inertia, force, center of gravity, rotational inertia, wave-motion, longitudinal wave, transverse wave.

2. Definitions for—motion, velocity, acceleration, dyne, gram-force, pound-force, moment of force, work, erg, gram-centimeter, foot-pound, energy, potential energy, kinetic energy, horse-power, efficiency, density, wave-length, period, frequency, amplitude.

3. Statement of the following laws or principles—laws of uniformly accelerated motion, starting from rest; Newton's three laws of motion; parallelogram, or triangle, of forces; moments; conservation of energy; machines; law of gravitation; pressure in liquids due to weight; principle of Archimedes, flotation; Pascal's law; pressure due to the atmosphere; Boyle's law.

4. Knowledge of the numerical values for—acceleration due to gravity, horsepower, standard temperature and pressure, weight of one cubic centimeter of water, weight of one cubic foot of water.

Sound.

5. Descriptions of—resonance, interference, beats.

6. Definitions for—fundamental, over-tones, octave.

7. Knowledge of the numerical value for—the speed of sound in air at 0° C., and the effect of change in temperature upon it.

8. Knowledge of the three characteristics of a musical tone and the physical basis of each.

Heat.

9. Descriptions of—conduction, convection, radiation.

10. Definitions of—boiling point, freezing point, calorie, latent heat, specific heat, coefficient of expansion, dew-point, humidity, relative humidity.

11. Statement of the following laws or principles—law of boiling, law of melting, law of Charles, mechanical equivalent of heat.

12. Distinction between heat and temperature.

13. Description of phenomena when ice at —10° C. is heated until it becomes steam at 115° C.

14. Knowledge of numerical values for—coefficient of expansion of gases, latent heat of fusion of ice, latent heat of vaporization of water, amount of work equivalent to one calorie.

Magnetism.

15. Description of—magnet, magnetization, magnetic poles, magnetic field, earth's magnetism, declination, inclination.

16. Quantitative statement of the law of magnetic poles.

Electrostatics.

17. Description of the production of—equal and opposite electrical charges by contact, by induction.

18. Quantitative statement of the law of electrostatic charges.

Electric Currents.

19. Description of—conduction, voltaic cell, electrolysis, series, parallel, electromagnetic induction.

20. Practical definitions of—ampere, ohm, volt, watt.

21. Statement of the following laws or principles—Ohm's law; relation between direction of current and resulting magnetic field; effect of iron in a magnetic field; induced currents—production, magnitude, direction; dependence of electrical resistance upon dimensions and material; heating effect of currents; distribution of current in a divided circuit of two branches.

Light.

22. Description of—rectilinear propagation of light, formation of images, shadows, reflection, refraction, total reflection, dispersion and spectrum.

23. Definition of—angles of incidence, reflection, and refraction, index of refraction, principal focus, focal length, conjugate foci.

24. Distinction between real and virtual image.

25. Statement of the following laws—reflection, refraction.

26. The characteristics of image for different distances of object from a convex lens.

27. Knowledge of the numerical value for the velocity of light.

III. Related Subject Matter.

Related subject matter will necessarily differ with the character of the class, conditions under which work is done, text book used, and many other influences. Its selection must, therefore, be left to the teacher as pointed out in sections 3 and 4 of the "General Statement."

The topics to be included under related subject matter are such as pumps, vibration of strings and organ pipes, steam engine, electric bell, telegraph, telephone, dynamo, camera, telescope, and very elementary statements of some theories, as the molecular theory, the wave theory of light, etc.

GENERAL STATEMENT OF THE POLICY OF THE FEDERATION.

The officers of the Federation deem it advisable to make the following brief statement of plans and policy, for the information of associations which may be interested in joining the organization.

The general purpose of the Federation is to increase the efficiency of the federated (local) associations by bringing each of them into helpful co-operative relations with others that are working along similar lines in other parts of the country, and with the new Section L on Education of the American Association for the Advancement of Science.

The work of the Federation through its officers and committees is expected in the near future to be developed along the following principal lines:

As a clearing house for the federated societies the Federation will undertake to collect and to keep up-to-date information in regard to the work and the publications of these societies, and to aid as opportunity offers in the formation of new societies when needed.

As a publishing agency the Federation will systematically print such of this information as may be of general interest in simple bulletins or in reports in scientific periodicals. Each federated society will be furnished with a list of the principal papers published in its field, and available to its members by purchase or exchange.

As a co-operative organization the Federation will from time to time, of its own initiative or at the instance of a particular society, propose questions of general interest for the consideration of the federated societies, or appoint committees on questions of national scope in the teaching of science.

In relations with national societies, such as, for example, The American Association for the Advancement of Science, The National Educational Association, The National Society for the Promotion of Industrial Education, etc., the Federation will endeavor to secure due recognition of the interests of the associations composing it, and of the great body of teachers of science.

At its Chicago meeting the American Association for the Advancement of Science showed its interest in and approval of the movement by affiliating the new Federation with itself, and then extending to members of the Federated associations the opportunity of joining the association without the usual initiation fee.

In general, the Federation is expected in the future development of its policy to promote the advancement and improvement of science teaching in whatever manner may seem wise under the restrictions fundamental to its organization, which leave entire freedom of action to the federated associations, and which contemplate the transaction of Federation business mainly by correspondence, and with limited funds.

In spite of these limitations, it is the opinion of the officers of the Federation that it will fill an important need and render a valuable service. They confidently appeal on this basis for the support of associations which have not yet already joined the Federation, with the hope of beginning the work outlined at an early date.

H. W. Tyler, Association of Mathematics Teachers of New England.

R. E. Dodge, New York State Science Teachers' Association.

F. N. Peters, Missouri Society of Teachers of Mathematics and Science.

J. T. Rorer, Association of Teachers of Mathematics in the Middle States and Maryland.

C. R. Mann, Secretary, Central Association of Science and Mathematics Teachers.

NORTHEASTERN PENNSYLVANIA ASSOCIATION.

The science and mathematics teachers of northeastern Pennsylvania met in the Scranton High School building on February 29th and organized a local circle of the Science and Mathematics Section of the State Educational Association. The following program had been arranged and was enthusiastically carried out:

10 A. M.—1. "Algebra in the High School," M. H. Jordan, Scranton. Discussion by Theron G. Osborne, Luzerne, and L. P. Bierly, West Pittston. Prof. Bierly discussed the question, "Should Algebra be Taught before the High School?"

2. "Physics in the High School," Samuel B. Fares, Wilkes-Barre. Discussion by E. H. Meyers, Hazleton, and Miss Myrtle Bond, Plymouth Township. Miss Bond discussed the question, "How Far Should the Teacher of Physics be Governed by the Text Book?"

1:30 P. M.—1. Organization.

2. "Botany in the High School," R. N. Davis, Dunmore. Discussed by Miss Julia Pierce, Honesdale, and John S. Hosterman, Montrose.

3. "Commercial Arithmetic in the High School." Discussed by Chas. R. Powell, Scranton, and A. W. Moss, Wilkes-Barre.

4. "If all Sciences can not be taught in the High School, which should be; in what years?" General discussion.

The officers of the newly formed organization are: President, Samuel B. Fares, Wilkes-Barre; Vice-President, R. N. Davis, Dunmore; Secretary, Miss Julia Pierce, Honesdale; Treasurer, M. H. Jordan, Scranton; Executive Committee, John S. Hosterman, A. A. Welles, and L. P. Bierly.

The success of the program and organization was largely due to the efforts of Mr. J. L. Welter of Wilkes-Barre. A second meeting will be arranged for in the fall.

EASTERN ASSOCIATION OF PHYSICS TEACHERS.

The forty-ninth meeting of the Eastern Association of Physics Teachers was held March 25 in the physics lecture room of the Salisbury Laboratory, Worcester Polytechnic Institute, Worcester, Mass.

The general session was preceded by a meeting of the executive committee followed by a business meeting, when reports of standing committees were presented. Mr. A. N. Burke reported for the committee on magazine literature, Mr. Augustus Klock for the one on current events in physics, and Mr. N. Henry Black gave the report from the committee on new apparatus.

At 10:30 A. M. Professor Charles P. Steinmetz of Union College gave an address. This was followed by demonstration of apparatus by Prof. A. Wilmer Duff, Professor of Physics at the Worcester Polytechnic Institute.

(1) Duddell's Singing Arc Light.

(2) Braun's apparatus for the resonance of electrical waves.

(3) Drude's apparatus for the measurement of electrical waves.

(4) Boys' Gravitation Balance for finding the mean density of the earth and the constant of gravitation.

(5) The Glimmer Oscillograph applied to show the wave from the secondary of an induction coil.

These demonstrations were followed by an inspection of the physics laboratories, power house and shops.

The afternoon session was held in the lecture room of the engineering building. The address was given by Prof. Harold B. Smith, M.E., Professor of Electrical Engineering at the Worcester Polytechnic Institute, "High Voltage Power Transmission." This address was illustrated by lantern slides and by experiments involving the use of an electric current of 250,000 volts pressure. This extremely high voltage was never before employed in lecture room experiments, and the Eastern Association of Physics Teachers was the first to enjoy the exhibition.

After the address the association witnessed tests of the trolley car which is part of the equipment of the electrical laboratories. This car consists of a complete double truck, four-motor interurban car, mounted on wheels carried by axles which transmit the power to special electric absorption dynamometers.

A business meeting was held after this car test, when these officers for the coming year were elected:

President, Fred R. Miller, Boston English High School.

Vice-President, N. Henry Black, Roxbury Latin School, Boston.

Secretary, H. W. Le Sound, Milton Academy, Milton, Mass.

Treasurer, Percy S. Brayton, High School, Medford.

The members in attendance all felt that this meeting was one of the best in the history of the Association.

BOOK REVIEWS.

Problems and Questions on Algebra, by Franklin T. Jones, University School, Cleveland, Ohio. 38 pages, 30 cents a copy.

This little pamphlet contains 575 problems compiled from college entrance examination papers. They are arranged in three groups: I. To Quadratics. II. Through Progressions. III. Advanced. Teachers who are not compelled to prepare pupils for such examinations will find much of interest in these problems since they reveal the point of view of college instructors; and those who are under the "galling yoke" will be aided in their task by using this collection of complicated expressions for manipulation, and impracticable practical problems.

H. E. C.

The Eighteenth Annual Report of the Director of the Missouri Botanical Gardens, in addition to the statement relative to the garden and the fund that supports it, contains ten scientific papers. Two of these are by Director William Trelease upon "Additions to the genus Yucca," and "Agave macroacantha and allied eugaves"; two are by Dr. Hermann von Schrenk upon "Branch cankers of rhododendron," and "On frost injuries to sycamore buds." Among the other papers, one of particular interest is that by H. C. Life upon "Effect of light upon the germination of spores and the gametophyte of ferns," in which it is stated that under ordinary conditions, regardless of the presence of favorable temperature, fern spores do not germinate in darkness, that intensity of light affects the form of fern prothallia, and that weak light inhibits the production of archegonia and favors the production of antheridia.

O. W. C.

Graphic Algebra, by Arthur Schultze, Ph.D., Assistant Professor of Mathematics, New York University, Head of the Department of Mathematics, High School of Commerce, New York. Pp. 93. 80 cents net. The Macmillan Company. 1908.

This is a real and welcome addition to the literature of the graph. The opening sentence of the preface indicates clearly the author's point of view: "It is now generally conceded that graphic methods are not only of great importance for practical work and scientific investigation, but also that their educational value for secondary instruction is very considerable." This book is evidently written in the belief that graphic methods have educational value, since seventy-two pages are given to the representation and solution of equations, and only five pages of the appendix are given to the graphic solution of problems. There is great need of a good book on the use of squared paper to solve problems.

Part I of Graphic Algebra deals with general graphic methods. In the first chapter are the usual definitions, and the three following chapters discuss the graphic representation of a function of one variable, and the graphic solution of equations involving one and two unknown quantities. Part II treats of the solution of equations by means of standard curves. The author has devised a very ingenious series of methods for solving quadratics, cubics, and biquadratics by means of a standard curve and straight lines or circles. This book should be read by every teacher of secondary mathematics.

H. E. C.

Glaciers of the Canadian Rockies and Selkirks (Smithsonian Expedition of 1904), by W. H. Sherzer, Ph.D. 1907. 9.5 by 12.5 inches. 135 pages and 42 plates.

This is an original investigation of the Canadian glaciers extending from 1902 to 1905. It embodies careful discussion of the features, drainage, structure, and nourishment of the Victoria, Wenkchemma, Yoho, Illecillewaet and Asulkan glaciers, all in British Columbia about two hundred miles north of the boundary of the United States. Forbes' "dirt bands," seasonal stratification, bear den moraines, dirt zones, and the color of glacial water are especially interesting because of the new facts presented. The average geolog'st will welcome this contribution because there exists at present a scarcity of literature upon the American glaciers. The entire investigation was conducted with such care as to accuracy of the detailed facts that this monograph ought to stand as a model for further research in this field. In the hurry of the present day many volumes are written which are full of broad generalization and utterly unreliable when taken into the field for comparison with the facts. For the geologist who desires to make a field study of glaciers, no better place could be chosen than the Victoria glacier, and with Dr. Sherzer's accurate description in hand, very valuable results could be obtained. The plates are excellent, the original survey maps are clear and would be very serviceable in the field. This monograph is a valuable addition to the knowledge of and will increase the growing interest in the British glaciers.

W. M. GREGORY.

The twelfth edition of Professor L. H. Bailey's "The Principles of Agriculture," by The Macmillan Company, has recently appeared. The constantly increasing interest in agricultural education has been due in no small measure to the influence of this book, which first appeared in 1898 and which since that date has been corrected, enlarged, and republished so many times. In the first edition the author pointed out a very important thing which it is well for those interested in all industrial educat'on to remember. He said, and now repeats, in speaking of scientific agriculture, "Its purpose is to improve the farmer, not the farm. If the person is aroused, the farm is likely to be awakened. * * * If the educated farmer raises no more wheat or cotton than the uneducated neighbor, his education is nevertheless worth its cost, for his mind is open to a thousand influences of which the other knows nothing. One's happiness depends less on bushels of corn than on entertaining thoughts."

Although such an introduction m'ght lead some to suspect that the text matter of the book would be inspirational, as distinct from practical, such is not at all true, since Professor Bailey realizes that the worker is stimulated best through a keen interest in his work. A simple, straightforward scientific discussion of the farm in all its aspects composes the book. The material is such that the intelligent farmer can use the book to great advantage, basing the reading directly upon his everyday observations. At the same time the material is so presented as to make it admirable for use in school classes in agriculture. From

the point of view of the reviewer no book has come to hand which is better for use in elementary agricultural instruction. O. W. C.

All botanists are familiar with the works of Romeyn B. Hough in which he has presented so many helpful sections of woods mounted for use under the microscope and bound in books. But in many ways the most attractive piece of work done by this author is his "Handbook of the Trees of the Northern States and Canada," published by the author at Lowville, N. Y. The region covered by the handbook is that lying north of the northern boundaries of North Carolina, Tennessee, Arkansas, and Oklahoma, and east of the Rocky Mountains, extending southward in the Appalachian region to northern Alabama and Georgia.

The general plan of the book is to present the leading characteristics of the trees at all seasons of the year. To do this the presentation of each tree is grouped under six headings, five of which are illustrations, and the sixth text description. (1) The first includes photographs of leaves, flowers, or fruits taken against a measured background so that one may know the size of the specimen shown. The photographs were taken while the specimens were fresh, and the nature of the surfaces often show clearly in the reproductions. (2) Leafless twigs in winter condition are illustrated with such clearness that many difficult determinations are made possible thereby. (3) Typical bark of trees are photographed with a foot ruler to give not only bark character but tree diameter. (4) Wood-structure is beautifully illustrated in one or more species in each genus. (5) Maps indicating the geographical distribution of most of the species as they are found throughout the United States will prove of highest value to the general student and dendrologist alike. (6) The text-discussion fills out the part of the two pages given to each species, and contains a large amount of general as well as descriptive information.

Altogether the work is the finest thing of its scope yet published. It represents an enormous amount of work extending over a long period of years, and is work which will remain a most worthy monument to its author. The statement that it contains 470 pages, 690 excellent photographs, and 191 line engravings, by no means indicates the real magnitude of the work. Its price ($8.00) is not large when its quality and extent are considered. Many teachers and students will find this book of great value. Every general library and every school library in any way associated with instruction in natural history will profit by adding the book to its collections. O. W. C.

Physiography for High Schools. By Professor R. D. Salisbury, University of Chicago. Twenty chapters, 531 pages, 24 plates, 469 figures, diagrams, maps and half tones. $1.50. Henry Holt & Co.

Every new text in Physiography from the pen of a teacher has many points of interest to every other teacher of that subject. Such texts invariably reflect something of the author's point of view, organization of subject matter and methods of treating various topics as he has worked them out in the class room. A text book by so capable and efficient a teacher as the author of this book ought to be welcomed

by every physiography teacher because of the opportunity it thus gives of comparing his own point of view and experiences in teaching the subject with those of the author as they are reflected in the text. Nearly every topic bears the imprint of the author's experience as a teacher and the book gains much from having thus evolved from the class room.

This book covers the ground usually covered by the more recent of its predecessors, 300 out of the 531 pages being devoted to the lands and land forms, 16 to earth relations, 138 to the atmosphere, climate, etc., 36 to the ocean and 23 to the effect of physiography upon plant and animal life. This chapter on plant and animal life was written by Dr. H. C. Cowles and Mr. Charles C. Adams, both of the University of Chicago and both specialists in those strictly modern sciences of plant and animal ecology.

The illustrations are well selected and numerous, thus forming a most valuable feature of the book. The chapter on weather maps as a single illustration contains 24 full page and half page weather maps, illustrating various weather types and furnishing material for the inductive treatment of that topic. The clear, easy style of the writing makes the book particularly valuable as a text in the earlier years of the high school course. The chapters dealing with the work of running water and of snow and ice are remarkably well written and lie within the author's special field of investigation. A high average of excellence has been reached in all chapters and the book ought to find a large place in the schools.

The reviewer has found from his experience with other texts that it has been quite impossible for him to anticipate from the reading of a new text how it will stand the test of actual class use. He is therefore glad to be able to add as a sort of a testimonial the statement that he has been using this text since it first appeared from the press some two months ago with a class of students who are about ninth graders, and this experience has demonstrated to the writer's satisfaction that the book possesses that much-to-be-desired though often rare quality in a text of being what might well be called teachable.

R. D. Calkins.

Central State Normal School, Mt. Pleasant, Mich.

Elements of Biology, a practical text-book correlating botany, zoölogy, and human physiology, by G. W. Hunter, Instructor in Biology, De Witt Clinton High School, N. Y. Pp. 445; illustrated. American Book Company.

The author states that the aim of the book is to correlate the allied subjects of botany, zoölogy, and human physiology in a general course of biology for the first year of the high school. This task is certainly a formidable one, for it is no easy matter to discuss fairly, even in an elementary way, three sciences within the limits of a book of 450 pages. It may also be questioned whether a science involving a discussion of such complex processes as those of human physiology can be successfully treated in the first year of the high school, before the pupils have become acquainted with the principles

of physics and chemistry. Finally it may be doubted whether the knowledge of plant life and plant structure which could be acquired by a high school pupil in one-third of the school year should be dignified by the name of science. The first 178 pages are given to botany and the author has arranged the various parts of the subject according to the availability of material during the autumn months. The various chapters deal with the following topics in the order given: protoplasm and the cell; flowers and fruit; seeds and seedlings; roots and their work; buds and stems; leaves and their functions; ecology; and flowerless plants. The order does not appear to be a logical one for any consideration of the subject which is serious enough to deserve the name of science, although quite suitable for the nature study aspect of plant life. If this treatment of the subject is not to be characterized as disconnected and illogical, the reader will at least be quite ready to agree with the author's statement in the introduction. that "it is thought that each successive chapter, although related to that immediately preceding it, is yet distinctive enough to allow of the omission of a chapter or chapters without in any way interfering with the continuity of the work."

It is to be regretted that the author's point of view does not always seem to be the most modern; for example, "flowerless" plants are discussed, all parts of a flower are regarded as homologous to each other and also to leaves, "polycotyledons" are mentioned as a group of plants of equal rank with monocotyledons and dicotyledons, and among the reference books recommended for the teacher are Goodale's Physiological Botany and Gray's Structural Botany.

The plant morphology is necessarily made up largely of a series of definitions of terms. The half dozen pages given to ecology provide for a very inadequate treatment of a phase of botany which should find a large place in any well organized high school course.

A large number of simple experiments in plant physiology are described and suggested. This is the most desirable feature of the botanical part of the volume. Occasionally simplification is carried to such an extent as to give a mistaken idea of the process involved. This error seems to have been made in the discussion of photosynthesis, which is constantly spoken of as starch formation and is illustrated by a too simple diagram.

The attention given to the economic importance of plants and plant structures is to be commended, for this phase of botany certainly has a place in any high school course. Even more space could with advantage have been given to such topics as plant breeding, forestry and lumbering.

Zoölogy has 140 pages devoted to its discussion. The arrangement is more logical than that adopted in the botanical part of the volume, the great groups of animals being taken in the order of the complexity of structure, from the Protozoa to the Mammals. The usual type forms are discussed briefly. The nature study and economic aspects of animal life receive considerable attention and the treatment is perhaps as good as could be given when it is found necessary to compress

a course in zoölogy into less than 150 pages, to occupy less than a half year of the high school course.

The portion of the book devoted to human physiology contains brief descriptions of the various vital processes rather than any experiments by which these processes may be demonstrated. These descriptions seem to be clear and accurate. As is usual in school text-books, the discussions of alcohol receive an amount of attention which is disproportionately large, but the subject is well handled and the latest results of investigators fairly and clearly stated. The author has given a scientific treatment of the effect of alcohol on the various activities of the human body which by its fairness and its prominence will recommend this part of his book to the advocates of temperance.

Rather extensive lists of reference books for both pupils' and teachers' use are given at the end of each chapter. These lists contain most of the best books on the subject under discussion, but also a few which are interesting principally from the place they have held in the development of science. The book is very well printed and bound, and, while the illustrations leave something to be desired in quality and size, they are numerous, suggestive, and many of them original.

GEO. D. FULLER.

SCIENCE ASSOCIATIONS EXCURSION.

The N. E. A. meets in Cleveland, June 27 to July 3, 1908. A few hours' ride away by boat is Kelley's Island, and a short distance further is Put-in-Bay. At the former place all the industries associated with a limestone quarry are carried on. The island itself is a solid bed of limestone containing innumerable fossils of considerable variety which are very easily accessible. The chief point of interest on Kelley's is, however, the glacial grooves. These indisputable evidences of glacial action on an immense scale are now preserved on a reservation owned by the State. To a teacher of the Natural Sciences these are of even greater interest than to the sightseer.

On Put-in-Bay Island are the fish-hatchery, various natural caves, and especially Crystal Cave, which contains not only the largest deposit of Celestite in the world but crystals that far surpass in beauty and size any other similar deposits.

A committee of the Central Association of Science and Mathematics Teachers will undertake the conduct of an all day lake excursion to these points of interest if there is sufficient demand to justify plans. About 600 people at about $1.00 each will be necessary to pay expenses. If more can be obtained, more can be done for the comfort and amusement of those who take the trip, as this is not designed to be a money-making affair.

Individuals and associations that are interested in making this a success are requested to notify Franklin T. Jones, University School, Cleveland, O. If a sufficient response is received, preparations will be pushed to carry out the plans outlined above.